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IDC RE-ENGINEERING REPORT

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IDC Re-Engineering Phase 2 Iteration E2 Use Cases

Version 1.0

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Abstract

This document contains 21 use cases generated from the model contained in Rational Software Architect.

REVISIONS

Version	Date	Author/Team	Revision Description	Authorized by
1.0	7/8/2016	SNL IDC Re-Engineering Team	Initial Release for E2	M. Harris
1.1	1/3/2017	SNL IDC Re-Engineering Team	Updated version redelivered in E3	M. Harris

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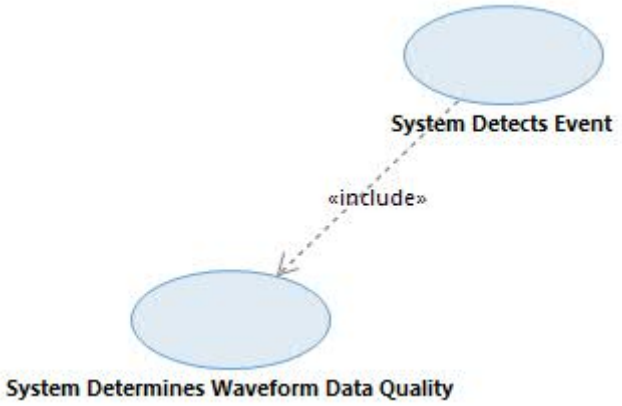
IDC Use Case Report

UC-02.01 System Determines Waveform Data Quality

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the System determines quality of waveform data. The System masks data with data quality errors, including data authentication problems. Depending on configuration settings, the System repairs, uses as-is, or excludes from processing data with quality errors. (see 'Configures Processing Components' UC).

ACTOR DESCRIPTIONS

None.

PRECONDITIONS

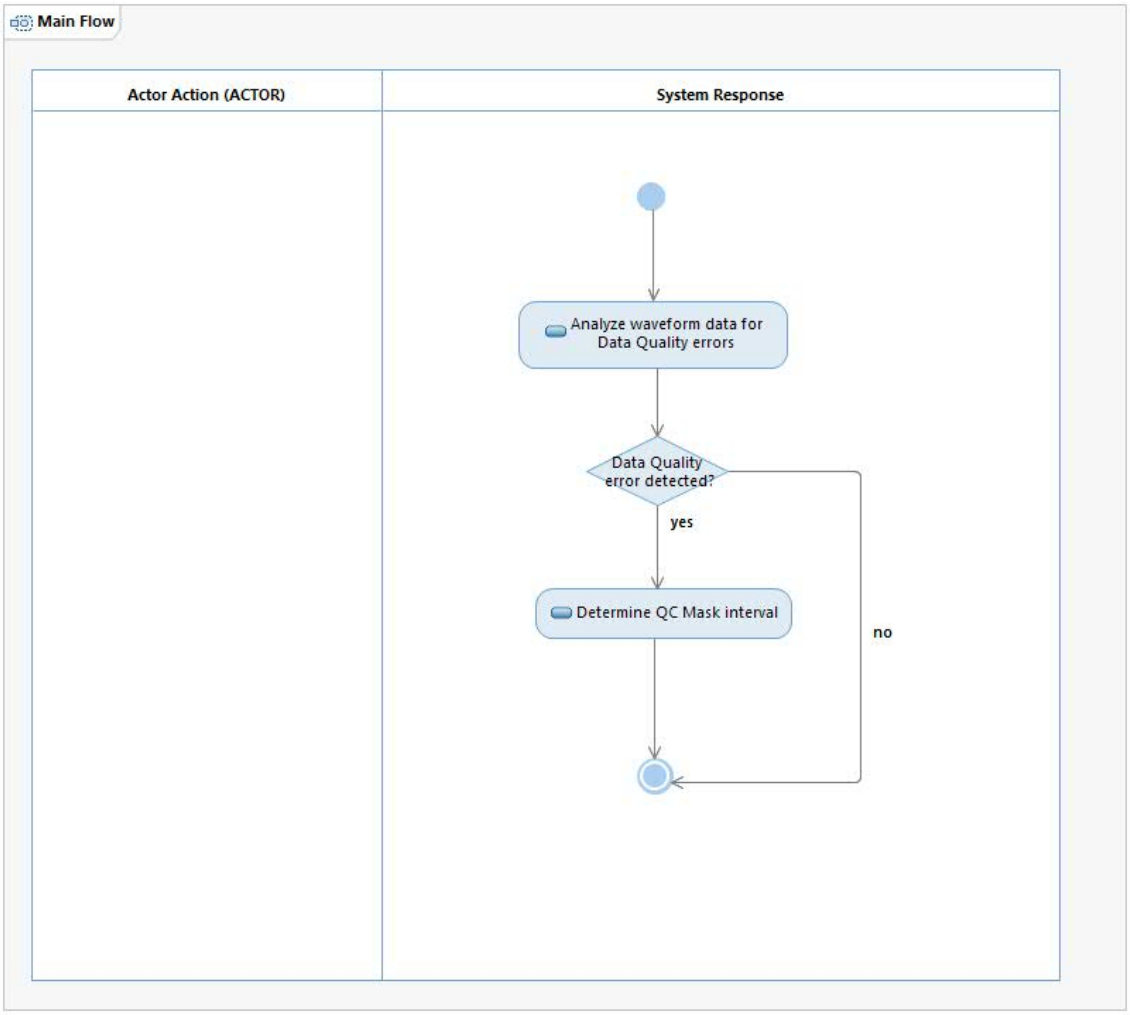
None.

POSTCONDITIONS

1. Waveform QC Masks are created for waveform sections containing data quality errors.

ACTIVITY DIAGRAMS

Main Flow



Action Descriptions

Action: "Analyze waveform data for Data Quality errors"

When waveform data is acquired, the System checks for data gaps, amplitude spikes, repeated amplitude values, timing errors, and linear trends. The System checks if the received waveform is a calibration signal or if the station has an invalid gain. The System determines if the number of data sample errors exceeds a configured threshold. The System checks if a channel from a multichannel station is noisy compared to the other channels. The System checks status and State-Of-Health information for the station generating the waveform data (reported by the station in the data header). All these cases could result in a data quality error. Additionally, the System checks authentication of the data (see 'System Receives Station Data' UC).

Action: "Determine QC Mask interval"

The System determines the mask start time by finding the first sample containing errors that exceeds a configured percentage of allowed errors (see 'Configures Processing Components' UC). The System determines the mask end time by determining when the conditions leading to the QC Mask are no longer satisfied.

Alternate Flows
None.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1253: [*Threshold*] The System shall automatically identify waveforms containing repairable data gaps.

S-1254: [*Threshold*] The System shall automatically create a Waveform QC Mask for a waveform containing a long data gap.

S-1255: [*Threshold*] The System shall automatically identify waveforms containing amplitude spikes.

S-1256: [*Threshold*] The System shall automatically create a Waveform QC Mask for a waveform containing an amplitude spike.

S-1257: [*Threshold*] The System shall automatically identify waveforms containing repeated adjacent amplitude values.

S-1258: [*Threshold*] The System shall automatically create a Waveform QC Mask for a waveform containing a repeated amplitude value data error.

S-1259: [*Extensibility*] The System shall automatically identify waveforms containing linear trends in amplitude.

S-1260: [*Threshold*] The System shall automatically fit linear trends to waveform data.

S-1261: [*Extensibility*] The System shall automatically create a Waveform QC Mask for a waveform containing a waveform linear trend data error.

S-1262: [*Threshold*] The System shall automatically create a Waveform QC Mask for a waveform containing a calibration signal.

S-1264: [*Threshold*] The System shall automatically create a Waveform QC Mask for a waveform containing invalid gain.

S-1265: [*Threshold*] The System shall automatically identify the percent of data samples in a waveform section containing data errors.

S-1266: [*Threshold*] The System shall automatically create a Waveform QC Mask for a waveform section containing errors in more than the allowed percentage of data samples.

S-1267: [*Threshold*] The System shall maximize the length of a Waveform QC Mask created for a waveform section containing errors in more than the allowed percentage of data samples.

S-1268: [*Threshold*] The System shall begin a Waveform QC Mask created for a waveform section containing errors in more than the allowed percentage of data samples on a sample containing a data error.

S-1269: [*Threshold*] The System shall terminate an automatically created Waveform QC Mask when the condition leading to the creation of that Waveform QC Mask is no longer satisfied.

S-1270: [*Threshold*] The System shall use State-of-Health information acquired from stations to identify waveform sections known to contain data errors and create Waveform QC Masks for those sections.

S-1271: [*Threshold*] The System shall create a Waveform QC Mask for a channel from a multichannel station containing noisy data relative to the other channels from that station.

S-1296: [*Threshold*] The System shall store the processing time period(s) during which each Waveform QC Mask was applied to the underlying waveform data.

S-1297: [*Threshold*] The System shall store the Waveform QC Masks applied to the waveform data used for each waveform processing operation.

S-1298: [*Threshold*] The System shall store the channel masked by each Waveform QC Mask.

S-1299: [*Threshold*] The System shall store the identity of the user or processing stage creating each Waveform QC Mask.

S-1300: [*Threshold*] The System shall store the identity of the user or processing stage modifying each Waveform QC Mask.

S-1301: [*Threshold*] The System shall store the identity of the user or processing stage removing each Waveform QC Mask.

S-1302: [*Threshold*] The System shall store the time of each Waveform QC Mask creation.

S-1303: [*Threshold*] The System shall store the time of each Waveform QC Mask removal.

S-1304: [*Threshold*] The System shall store the time of each Waveform QC Mask modification.

S-1305: [*Threshold*] The System shall store the type of error being masked for each automatically created Waveform QC Mask.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-5592: [*Threshold*] The System shall automatically identify waveforms containing long data gaps.

S-5593: [*Threshold*] The System shall create a Waveform QC Mask for a channel containing noisy data relative to a global noise model.

S-5594: [*Threshold*] The System shall create a Waveform QC Mask for a channel containing noisy data relative to a station noise model.

S-6219: [*Threshold*] The System shall automatically identify waveform data that fails data authentication.

S-6220: [*Threshold*] The System shall automatically create a Waveform QC Mask for waveform data that fails data authentication.

S-6495: [*Objective / Priority 2*] The System shall automatically identify waveform data containing timing errors.

S-6496: [*Objective / Priority 2*] The System shall automatically create a Waveform QC Mask for waveform data containing timing errors.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Data Quality Errors - Errors in waveforms that can lead to problems with processing and analysis. Data quality errors include data gaps, amplitude spikes, repeated amplitude values, linear trends, and invalid gain. Prior to signal processing, data are analyzed by quality control (QC) software to identify and record any errors (see Waveform QC Mask).

QC Mask - See waveform QC mask.

Quality Control (QC) - See waveform quality control.

Random Binary Calibration - A method to determine the frequency response of a sensor using a random binary signal applied to the sensor calibrator input. A random binary signal is a sequence of step functions of identical amplitude but randomly varying polarity. The random binary signal may be a known signal or may be recorded as an independent channel at the sensor. The sensor

frequency response is calculated using the cross-spectrum of the sensor output to the input random binary signal.

Waveform QC Mask - The tag applied to a segment of waveform data with a QC (see waveform quality control) problem. Each QC mask includes a start and stop time and a description of the type of problem. Subsequent waveform processing algorithms may use this information to mask (i.e., ignore) these segments.

Waveform Quality Control - The processing of waveform data to identify problems related to data acquisition and/or transfer (e.g., dropouts, spikes). In particular, waveform quality control is focused on identifying problems that can lead to false signal detections and/or to missed true signal detections.

IDC Specific:
None.

NOTES

General:
1. The System should not automatically correct for data quality errors. The System can correct data errors during signal processing (e.g., interpolating short gaps, filling gaps with noise for subspace detectors). The errors/mask types that can be corrected and the processing component where the correction occurs are configurable.

2. The System Maintainer configures the exclusion of processing of QC masked data for each processing component (see 'Configures Processing Components' UC).

3. Late arriving data that fills a data gap removes the data gap mask (the history of QC masks is preserved). The late data is then checked for other data quality issues.

4. PKI authentication failure is detected in 'System Receives Station Data' UC. 'System Determines Waveform Data Quality' UC applies a mask to the waveform sections that have authentication failures.

5. The execution order of mask application is configurable on a per sensor basis. See 'Configures Processing Components' UC.

6. Although this Use Case does not store data, this Use Case maps to storage specifications because it creates data that is stored in other Use Cases. See 'System Detects Event' UC.

IDC Specific:
None.

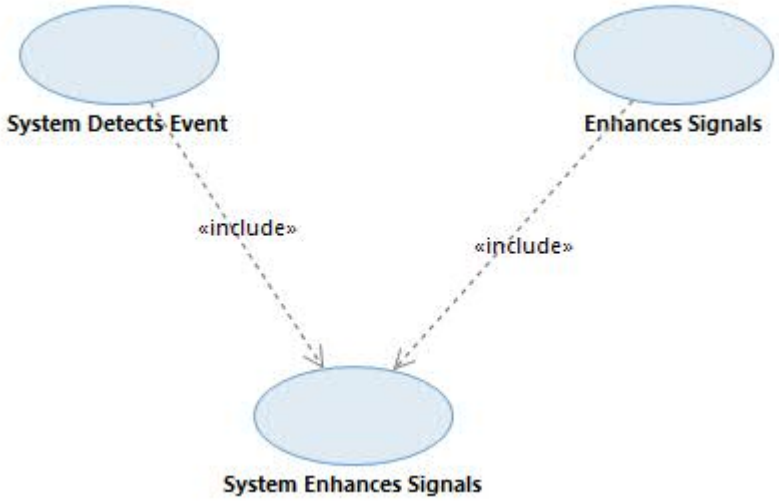
OPEN ISSUES

None.

IDC Use Case Report

UC-02.02 System Enhances Signals

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the System processes waveform data to enhance event signals while suppressing background noise. The System creates derived channels from input channels using signal enhancement techniques including filtering, rotation, and beaming. The System also resamples channels and deconvolves instrument response to convert raw channel sample counts to earth displacement. Additionally, the System creates fk spectra, spectrograms, and detection feature maps which are based on processing one or more waveforms from a station for a particular feature of the waveform.

The System filters raw channels to isolate frequency content in the presumed bandwidths of arriving signals. The System uses various filter configurations to both optimize the enhancement of different signal arrival types and to account for the unique characteristics of individual raw channels.

The System rotates raw channel data from 3-component seismic stations to align the data's axes to a specific azimuth and slowness rather than to the physical instrumentation's coordinate system. Rotation produces derived channels corresponding to an arriving signal radial, transverse horizontal, and transverse vertical (3-dimensional rotation only) ground motion components.

The System forms continuous and segmented beams for array stations using array element channel data. The System computes beams for each array providing targeting on specific areas of interest, specific event hypotheses, and wide area coverage.

The System creates Detection Feature Maps of coherent signal power (e.g., fk spectra, 3-component fk spectra, progressive multiple channel correlation pixel maps) or signal frequency content (e.g., spectrograms) from a set of waveforms over a specified time interval.

The System uses default signal enhancement parameters configured by the System Maintainer for pipeline processing (see ‘Configures Processing Components’ UC), override parameters set by the Analyst (see 'Enhances Signals' UC), or parameters derived from earth models or historical processing results to support an iterative, feedback-based processing sequence (see 'System Builds Events using Signal Detections' UC).

ACTOR DESCRIPTIONS

None.

PRECONDITIONS

1. At least one channel is available for processing. Input channels may include both raw and derived channels.

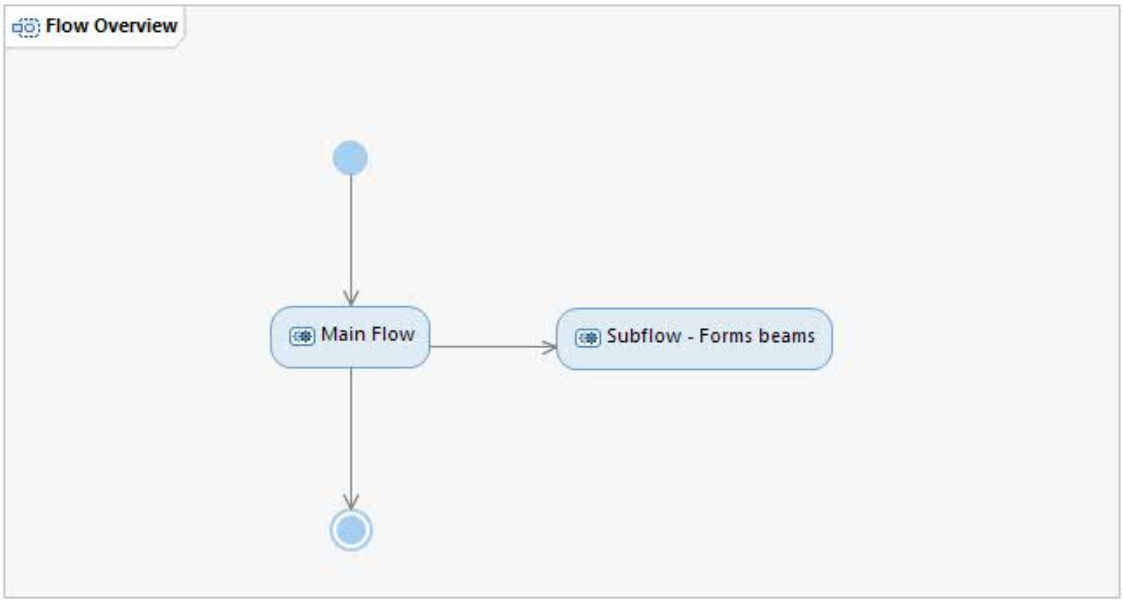
2. QC mask information and corrected waveforms are available.

POSTCONDITIONS

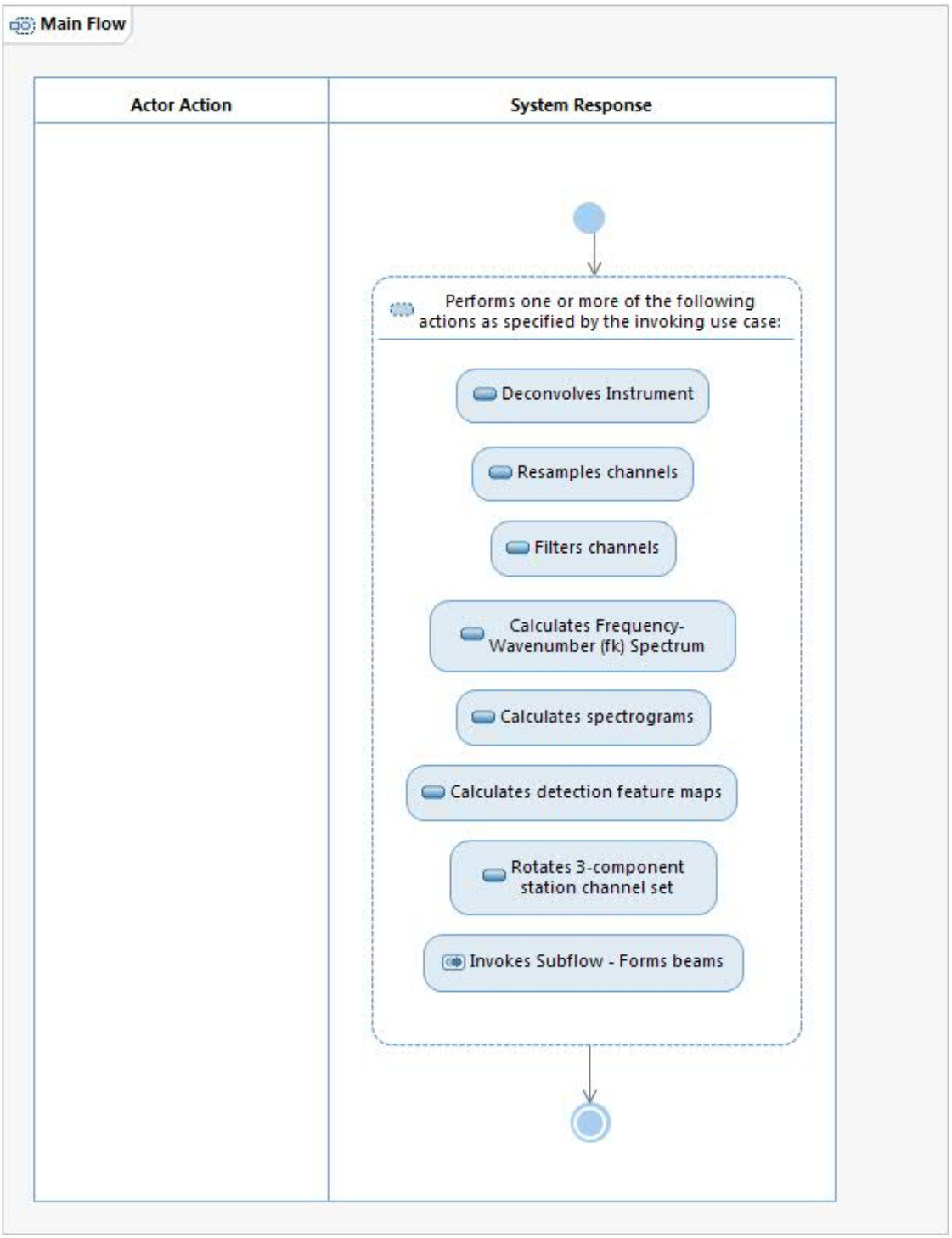
1. The System has created one or more derived channels, including filter group delays and associated metadata including the applicable instrument deconvolution parameters, filter parameters, rotation parameters, and beam parameters used to create the derived channel(s).

ACTIVITY DIAGRAMS

Flow Overview



Main Flow



Action Descriptions

Action: "Deconvolves Instrument"

The System removes instrument response delays and converts instrument samples to earth displacement for the set of input channels and time interval specified by the invoking use case. This process results in a corresponding set of derived channels. The System uses station instrument response information in order to perform the deconvolution.

Action: "Resamples channels"
The System resamples the set of input channels at the target sample rate for the specified time interval, creating a corresponding set of derived channels. The invoking use case specifies the input channel set, time interval, and target sample rate. Depending on the relationship between the sample rate of the input channels and the target sample rate, the System will either upsample or downsample the input channels. The System maintains a constant phase offset while resampling.

Action: "Filters channels"
The System applies one or more filters to the set of input channels (using the filter transfer function coefficients) for the specified time interval, creating a corresponding set of derived channels and associated group delays. The invoking use case specifies the input channel set, time interval, and the filter or cascade of filters to apply. The System maintains a library of filters that may be applied to incoming channel data, either by Analyst selection (see 'Enhances Signals' UC) or through configuration of automated processing (see 'Configures Processing Component' UC).

Action: "Calculates Frequency-Wavenumber (fk) Spectrum"
The System conducts an fk analysis on waveforms from a seismic or infrasonic array station to estimate the signal's azimuth and slowness. The System transforms the array data from a short time window around a time provided by the invoking use case into a frequency-wavenumber power spectrum. The System uses a two-dimensional interpolation to refine the coordinates of the peaks in the fk power spectrum. The System calculates the F-statistic for the fk power spectrum.

Action: "Calculates spectrograms"
The System calculates spectrograms for the set of input channels for the specified time interval. The invoking use case specifies the input channel set, time interval, and frequency resolution, and overlap.

Action: "Calculates detection feature maps"
The System calculates detection feature maps, a matrix of values for a particular feature measured at a particular station over time.

Action: "Rotates 3-component station channel set"
The System rotates the channels of a specified 3-component station for a specified time interval from the instrumentation's coordinate system to a coordinate system aligned to a specified azimuth & slowness pair. The result is a set of derived channels. The invoking use case specifies the input channels corresponding to the station of interest, the time interval, the target azimuth & slowness pair, and the type of rotation to be applied (2-dimensional or 3-dimensional).

Action: "Invokes Subflow - Forms beams"
The System applies beam processing to the array channel set & target azimuth/slowness pair for the specified time interval in order to create a set of derived channels containing summed time series samples across the array elements for each component. The invoking use case specifies the

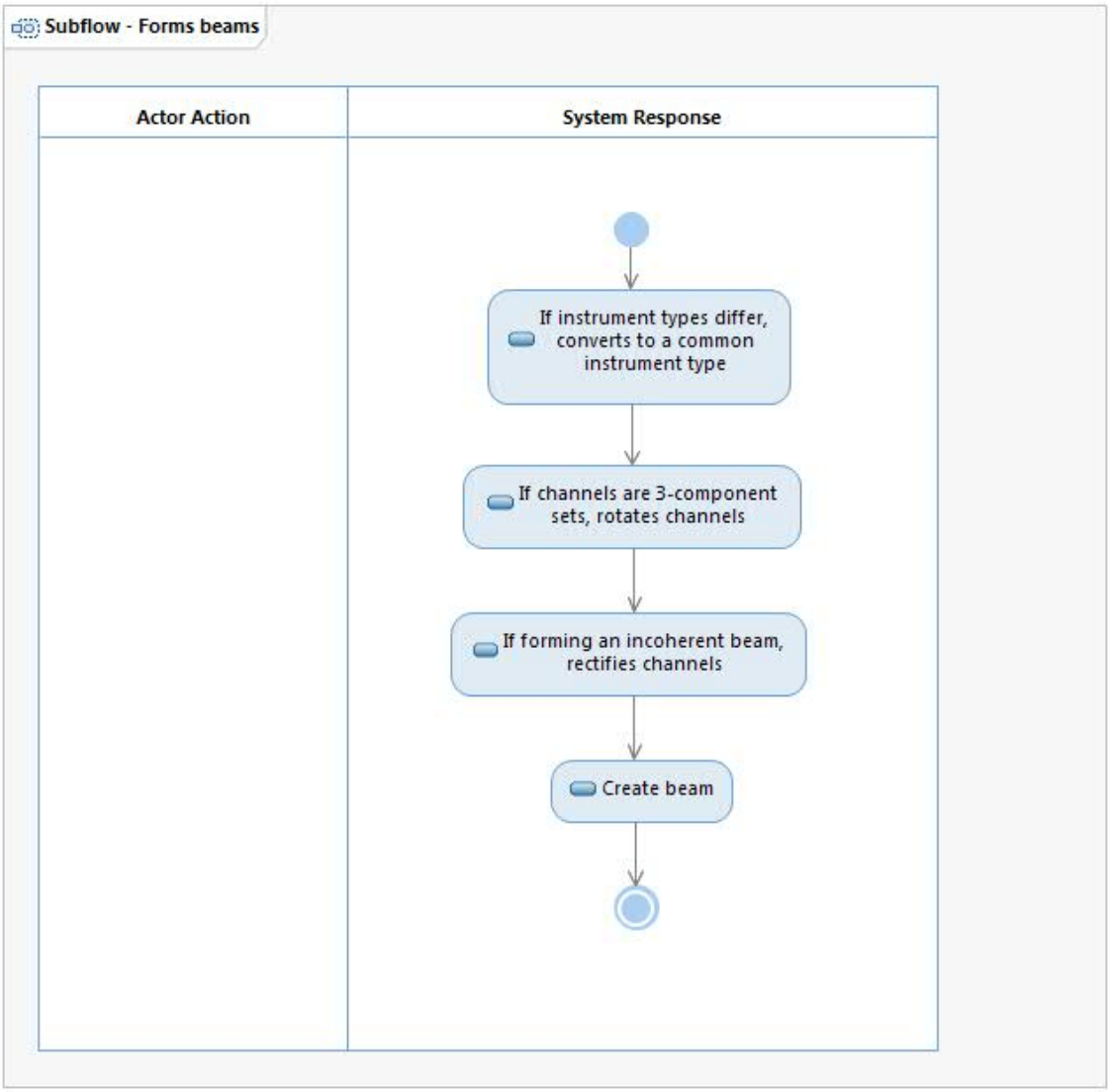
channel set, azimuth/slowness pair, time interval & target sample rate (if resampling), as well as the type of beam to form (coherent or incoherent) and domain (time or frequency). The channel set represents the elements of a single array station.

Alternate Flows

1. Action "Filters channels" - The System will not apply a specified filter to a specified input channel if the difference between the filter's sample rate and the channel's sample rate is greater than the filter's sample rate tolerance. In this case, the System will generate a notification.

2. All Actions - The System will exclude waveform sections containing QC masks from signal enhancement processing, if configured to do so.

Subflow - Forms beams



Action Descriptions

Action: "If instrument types differ, converts to a common instrument type"

In cases where the array elements selected for beam formation are of differing instrument types, the System applies a transfer function to convert the provided channels to a common instrument

type. In practice, there are three instrument types - Long-Period (LP), Short-Period (SP), and Broadband (BB) - arranged in two array station configurations:

1. LP Array: A Set of LP sensors, possibly with a BB sensor
2. SP Array: A set of SP sensors, possibly with a BB sensor

This step is used to convert BB waveforms into either an equivalent LP (BBLP) or an equivalent SP (BBSP) waveform prior to beaming with the other array station channels. Conceptually, the applied transfer function includes the following three steps:

1. Deconvolve the BB instrument response
2. Convolve the LP or SP instrument response
3. Downsample as needed (i.e., to convert to LP)

This step produces a derived channel corresponding to each BB input channel that was converted. The invoking use case specifies the array station input channel set and time interval. The System maintains the necessary conversion information (instrument responses and sample rates).

Action: "If channels are 3-component sets, rotates channels"
The System rotates the channels of a specified 3-component seismic station for a specified time interval from the instrumentation's coordinate system to a coordinate system aligned to a specified azimuth & slowness pair. The result is a set of derived channels. The invoking use case specifies the input channels corresponding to the station of interest, the time interval, the target azimuth & slowness pair, and the type of rotation to be applied (two-dimensional or three-dimensional).

Action: "If forming an incoherent beam, rectifies channels"
When forming an incoherent beam, the System rectifies (converts to absolute values) the time series samples for the specified array channels and time interval. The invoking use cases specify the input channel set as well as the time interval.

Action: "Create beam"
The System shifts the channel samples to correct for the corresponding array element's signal offset from the array beampoint. This process results in a set of derived channels whose sample data are aligned for the particular azimuth/slowness pair. The System then sums the channel samples for each array element and scales the resulting values to the amplitude range of the input channels. In the case of a three-component array, separate summations are made for each of the rotated components. This process results in a set of derived channels for the specified time interval. This process can either be done in the time domain or frequency domain.

The invoking use case specifies the input channel set as well as the time interval, azimuth/slowness pair, and time/frequency domain. The input channels represent the elements of an array station.

Alternate Flows
None.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1273: [*Threshold*] The System shall select to process waveform data containing a QC Mask based on configured parameters.

S-1312: [*Threshold*] The System shall provide a waveform filter library containing commonly used filters.

S-1313: [*Threshold*] The System shall filter waveforms using the coefficients from the numerator and denominator of the filter's transfer function.

S-1314: [*Threshold*] The System shall downsample waveforms (filter and decimate).

S-1315: [*Threshold*] The System shall apply a constant phase offset while downsampling waveforms.

S-1316: [*Threshold*] The System shall upsample waveforms.

S-1317: [*Threshold*] The System shall apply a constant phase offset while upsampling waveforms.

S-1318: [*Threshold*] The System shall cascade up to 10 filters.

S-1320: [*Objective / Priority 1*] The System shall compute the time shift of a filter's group delay from the coefficients of that filter's transfer function.

S-1321: [*Objective / Priority 1*] The System shall shift filter output waveforms to remove filter group delay.

S-1322: [*Objective / Priority 1*] The System shall automatically shift waveforms to remove recording instrument response delay.

S-1323: [*Objective / Priority 1*] The System shall remove recording instrument response from waveforms.

S-1324: [*Threshold*] The System shall remove a waveform's DC offset.

S-1326: [*Threshold*] The System shall convert amplitude measurements from measured counts to earth displacement.

S-1327: [*Threshold*] The System shall not apply a filter to any waveform for which the difference between the filter's sample rate and the waveform's sample rate is greater than the filter's sample rate tolerance.

S-1350: [*Threshold*] The System shall rotate the components of 3-component seismic waveform data from one 3-dimensional coordinate system to another 3-dimensional coordinate system.

S-1356: [*Threshold*] The System shall create beams using a specified set of channels.

S-1357: [*Threshold*] The System shall form coherent beams.

S-1358: [*Threshold*] The System shall form incoherent beams.

S-1359: [*Threshold*] The System shall form beams for specified time windows.

S-1360: [*Threshold*] The System shall form beams for specified azimuth and slowness pairs.

S-1361: [*Threshold*] The System shall compute continuous beams for virtual event hypotheses for predefined geographic regions.

S-1362: [*Threshold*] The System shall account for differences in array element sensor vertical position when forming beams.

S-1363: [*Threshold*] The System shall filter waveform data from individual channels before beam forming to make channel frequency content consistent across all channels in the beam.

S-1364: [*Threshold*] The System shall convert individual channels from measured counts to earth displacement before using the channels to form beams.

S-1365: [*Threshold*] The System shall first rotate 3-component data from each seismic array element before beaming to form radial origin beams for 3-component seismic arrays.

S-1366: [*Threshold*] The System shall first rotate 3-component data from each seismic array element before beaming to form transverse origin beams for 3-component seismic arrays.

S-1367: [*Threshold*] The System shall first rotate 3-component data from each seismic array element before beaming to form radial fk-beams for 3-component seismic arrays.

S-1368: [*Threshold*] The System shall first rotate 3-component data from each seismic array element before beaming to form transverse fk-beams for 3-component seismic arrays.

S-1371: [*Threshold*] The System shall notify the Analyst when any two channels selected for a beam have sample rates that differ by more than the beam's sample rate tolerance.

S-1386: [*Threshold*] The System shall store the beam definition parameters for all beams.

S-1387: [*Threshold*] The System shall store continuous beams for virtual event hypotheses for predefined locations.

S-1394: [*Threshold*] The System shall store derived waveform data with no related signal detections for the Operational Processing Time Period.

S-1468: [*Threshold*] The System shall calculate fk spectra for a set of waveforms.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2101: [*Threshold*] The System shall calculate spectrograms for any channel.

S-2165: [*Threshold*] The System shall generate virtual origin beams for a specified location for a time interval up to 2 hours and an array station up to 20 channels in less than 1 second.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-2359: [*Threshold*] The System shall account for differences in array element sensor vertical position when calculating fk spectra.

S-5630: [*Threshold*] The System shall compute infrasound closure and consistency measurements.

S-5631: [*Threshold*] The System shall convert amplitude measurements from measured counts to velocity.

S-5632: [*Threshold*] The System shall convert amplitude measurements from measured counts to acceleration.

S-5720: [*Threshold*] The System shall store spectrograms.

S-6197: [*Threshold*] The System shall create a time-series of maximum F-statistic values for specified time windows.

S-6199: [*Threshold*] The System shall filter waveforms using phase match filters.

S-6200: [*Threshold*] The System shall filter waveforms using autoregressive filters.

S-6201: [*Threshold*] The System shall filter waveforms using pseudo-correlation filters.

S-6467: [*Threshold*] The System shall create detection feature maps with the time and frequency dependent spatial coherence of waveforms.

S-6469: [*Threshold*] The System shall store detection feature maps.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Array - A group of stations (sometimes referred to as "elements") deployed with the intent of processing waveform data with specialized techniques exploiting signal coherence between the stations. This processing improves the signal-to-noise ratio (SNR) and also provides estimates of the direction (azimuth and slowness /velocity) of signals. Arrays are used for seismic, infrasonic, and hydroacoustic monitoring.

Array Coherence - A measure of the similarity of waveforms during a given time interval between the elements of an array. High array coherence indicates that a signal is propagating across the array.

Azimuth - The angle in degrees measured clockwise from geographic North of a signal arriving at a station. Azimuth and slowness completely describe the vector direction of arrival for a signal at a station.

Beam - The product of beamforming; a single derived channel (see channel, derived) representing the sum of the raw channels (see channel, raw) for all the elements of an array.

Beamforming (Beaming) - Beamforming (also known as beaming) is a multichannel signal processing technique taking advantage of the direction-dependent arrival of a signal across an the elements of an array. Beamforming sums the waveform data from the elements of an array to produce a single derived channel (see channel, derived). The intent is to boost SNR.

Beamforming (Beaming), Coherent - A method for increasing the SNR of signals arriving at an array from a particular azimuth and slowness. Coherent beamforming (also known as beam steering) time shifts the waveforms from an array's elements before summing, under the assumption that a plane wave is arriving from that direction. The shifting is done for each element by subtracting the time delay relative to the array beampoint (a reference location for the array) that would be expected for a plane wave arriving from that azimuth and slowness. If there is a signal arriving from the specified azimuth and slowness, an SNR gain occurs when summing the time delayed waveforms, due to the simultaneous constructive interference of coherent directional signals, and destructive interference of incoherent background noise. In theory, a gain of SNR equal to the square root of the number of elements can be achieved (e.g., a factor of 3 for a 9 element array). In practice, the realized gain is usually less.

Beamforming (Beaming), Incoherent - The same as coherent beamforming except that the waveforms are rectified (i.e., absolute values) before summing.

Channel, Derived - A source for time series data created by processing one or more raw channels (see channel, raw). Examples of common types of processing to form derived channels are filtering (see filter, waveform), beaming (see beamforming [beaming]), and rotation. Derived channels are generally created to enhance the SNR of signals.

Channel, Raw - A source for unprocessed time series data from a seismic, hydroacoustic, or infrasonic sensor (e.g., the output from a short period, vertical component seismometer).

Detection Feature Map - A matrix of values for a particular feature as measured at a particular station over time. The matrix contains a feature vector calculated for each point in time based on the processing of one or more waveforms from the station. The feature vector is a set of values indexed by secondary independent variables, for example, frequency. Detection feature maps are used to detect and identify signals. A spectrogram is an example of a detection feature map where the feature is signal amplitude and the index is frequency. Array coherence is another example where the feature is coherence (or another feature gated by a coherence threshold) and the index is frequency.

Filter Cascade - The application of two or more waveform filters (see filter, waveform) in series. Complex filters can be designed to meet a set of specific needs by applying a series of simple filters, each of which is designed to meet a more basic need. Once the sequence of filters is known, the successive filter operations can be replaced with a single filter operation equivalent to the filter cascade.

Filter, Waveform - An algorithm that operates on a waveform to produce a derived waveform with enhanced signal content relative to the background. The most common type of filtering limits frequency content (e.g., low-pass, high-pass, or band-pass). More complex types of waveform filters compare incoming data against a model, either of the background noise (autoregressive filter), or of the expected signal (phase match filter, pseudo-correlation filter).

Frequency-Wavenumber (fk) Power Spectrum - The representation in the frequency-wavenumber domain of coherent signal power in the waveform data from an array for a specified time interval. Calculation of fk power spectrum requires three Fourier transforms to convert time-sampling to frequency (designated by f), and longitude and latitude sampling to x and y wavenumbers (designated by k). Typically, fk power spectra are represented as 2D plots (not 3D), by collapsing the frequency information to a single value for each x and y slowness, by averaging values across the range of frequencies.

Frequency-Wavenumber (fk) Processing - A signal processing technique that can be applied to a short interval of waveform data from an array to determine if a signal is present and estimate the signal's azimuth and slowness. Waveform data are first converted to a frequency-wavenumber power spectrum and then further processing is done in the fk domain.

Rotation - A coordinate system transform that rotates raw channel (see channel, raw) data from a three component station to align the data's axes parallel and perpendicular to a specific azimuth and slowness (i.e., ray path). Rotation produces derived channels corresponding to an arriving

signal's radial and transverse ground motion. The purpose of rotation is to enhance the SNR of signals of interest.

Signal Enhancement - Signal processing techniques including filtering (see filter, waveform), beamforming, and three component waveform data rotation, used to enhance the signal content, and reduce the noise content of waveform data.

Slowness - A measure of the inverse apparent velocity of a wave moving across the surface of the Earth at a station. The inverse of slowness is the apparent velocity of such a wave. Slowness is often used in phase identification and is sometimes used for determining event location.

Three Component Station - A seismic station with separate instruments measuring ground motion in three perpendicular directions: up-down, north-south, and east-west. These directions are often referred to as Z, N, and E. Also referred to as a 3C station.

IDC Specific:
None.

NOTES

General:
1. The beam sequence shown in the Subflow-Forms Beams is notional. The sequence of actions is determined by 'Defines Processing Sequence' UC.

2. Although this Use Case does not store data, this Use Case maps to storage specifications because it creates data that are stored in other Use Cases. See 'System Detects Event' UC and 'Refines Event' UC.

IDC Specific:
None.

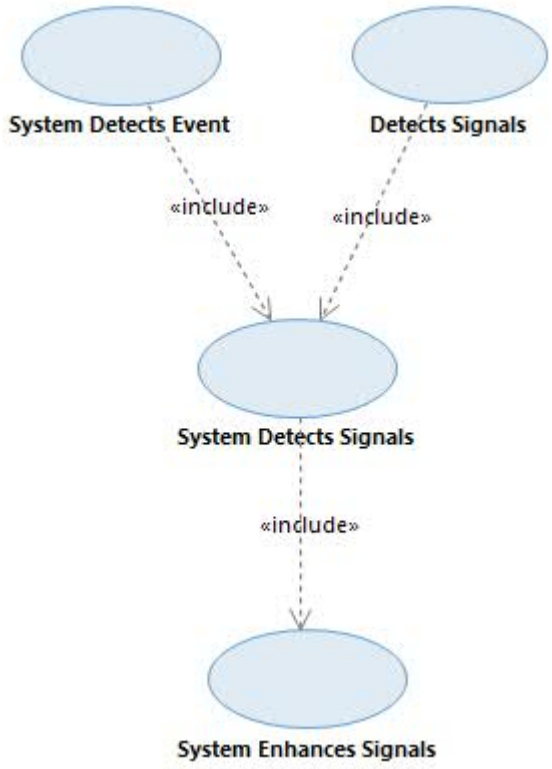
OPEN ISSUES

None.

IDC Use Case Report

UC-02.04 System Detects Signals

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the System detects signals in waveform data or products derived from waveform data like detection feature maps or frequency-wavenumber transforms. The System automatically and continuously detects signals on raw and derived channels (see 'System Enhances Signals' UC) with an acceptable data quality (see 'System Determines Waveform Data Quality' UC). Multiple signal detection algorithms are used to detect signals. The System declares detections when these signals on waveforms or derived products exceed a threshold value. The System refines the onset time of the detections. The System uses threshold values for signal detectors configured by System Maintainer (see 'Configures Processing Components' UC). Threshold values are configurable by type of detector and channel. The System stores all detections and respective attributes (such as type of detector).

The signal detection process can be guided using parameters derived from earth models or historical processing results that support an iterative, feedback-based processing sequence (see 'System Builds Events using Signal Detections' UC).

ACTOR DESCRIPTIONS

None.

PRECONDITIONS

1. At least one channel is available for processing. Input channels may include both raw and derived channels.

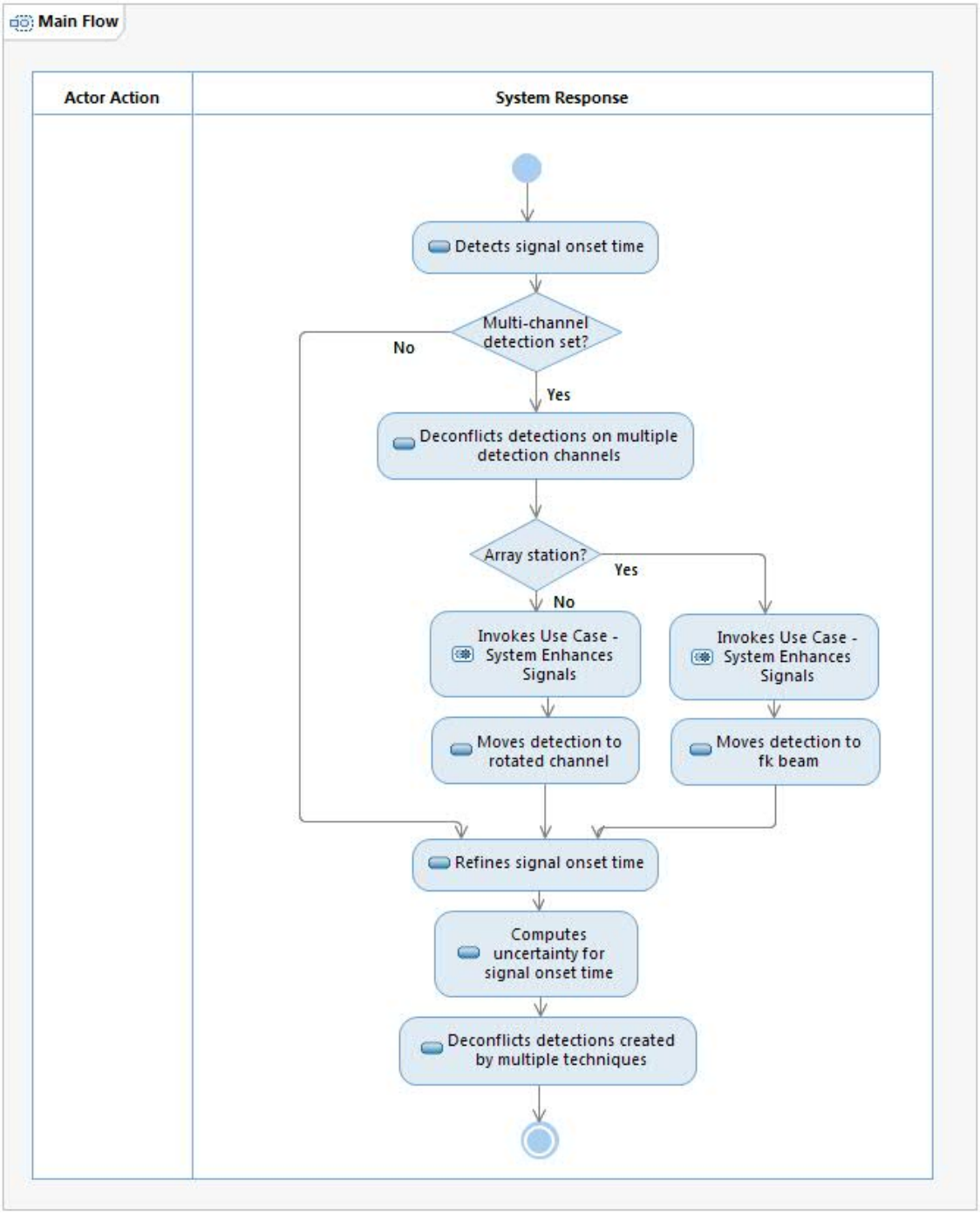
2. Zero or more expected signal detections are available.

POSTCONDITIONS

1. The System has created zero or more signal detections.

ACTIVITY DIAGRAMS

Main Flow



Action Descriptions

Action: "Detects signal onset time"

The System uses a variety of methods to detect the presence of a geophysical signal and its onset time on a raw or derived channel after checking the Waveform QC Mask. Examples of methods are listed below:

1. Power detector (STA/LTA)
2. Z detector
3. Log-Z detector
4. F detector (for an array station)
5. Spatial coherence (for an infrasound array station)
6. Phase match filter (for event-driven surface wave detection)
7. Waveform correlation (for specific signals from historic event hypotheses)
8. Progressive Multi-Channel Correlation (PMCC)

Signal detection parameters (e.g., threshold for declaring a detection) may vary by time of year and time of day.

Action: "Deconflicts detections on multiple detection channels"
A single geophysical signal may be detected on multiple detection channels (array beam channels or rotated three component station channels). The System will group detections on multiple detection beams based on onset time and beam parameters (e.g., azimuth and slowness). Multiple signals may arrive at an array or 3C station simultaneously; the System will allow multiple groupings at a specific time. The System will keep the best detection for each group based on SNR and discard the other detections.

Action: "Invokes Use Case - System Enhances Signals"
Invoke signal processing functionality in System Enhances Signals UC:
1. Rotate 3C channels to direction of highest signal power

Action: "Invokes Use Case - System Enhances Signals"
Invoke signal processing functionality in System Enhances Signals UC:
1. Calculate fk power spectra for the signal detection
2. Create beam steered to fk power spectrum peak

Action: "Moves detection to rotated channel"
Associates detection to rotated channel. The association to the original detection channel is also preserved.

Action: "Moves detection to fk beam"
Associates detection to fk beam channel. The association to the original detection channel is also preserved.

Action: "Refines signal onset time"
Refines the signal onset time using a method appropriate to the signal detection algorithm. Examples of methods are listed below.

1. The Akaike Information Criterion (AIC). AIC uses statistical models of the signal and noise to search for the time of transition in the waveform from background noise to signal.
2. Waveform cross-correlation. For signals detected with waveform correlation, corrections are based on waveform cross-correlation.

The technique used to refine signal onset time is configured by the System Maintainer (see 'Configures Processing Components' UC).

Action: "Computes uncertainty for signal onset time"
An estimate of measurement uncertainty for the detection time is computed.

Action: "Deconflicts detections created by multiple techniques"
Multiple detection techniques may be used for the same station and create duplicate signal detections for the same signal. The System will group detections from multiple techniques based on onset time, azimuth, and slowness. Multiple signals may arrive at an array or 3C station simultaneously; the System will allow multiple groupings at a specific time. The System will keep the best detection for each group based on SNR and discard the other detections.

Alternate Flows
1. Action "Detects signal onset time" - If expected signal detections are available then signal detection parameters included with the expected signal detections may be used.

2. Action "Deconflicts detections created by multiple techniques" - This use case may begin at this step to deconflict previously created signal detections (e.g., deconflict detections created by “System Detects Events using Waveform Correlation” UC with detections created by previously invoking “System Detects Signals” UC).

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1273: [*Threshold*] The System shall select to process waveform data containing a QC Mask based on configured parameters.

S-1393: [*Threshold*] The System shall store all derived channels related to one or more signal detections.

S-1397: [*Threshold*] The System shall use power detectors to form signal detections on waveforms.

S-1398: [*Threshold*] The System shall use Z detectors to form signal detections on waveforms.

S-1399: [*Threshold*] The System shall use log-Z detectors to form signal detections on waveforms.

S-1400: [*Threshold*] The System shall use F detectors to form signal detections on beams.

S-1401: [*Threshold*] The System shall detect signals of interest in waveform data by correlating the waveform with waveforms from historic event hypotheses.

S-1402: [*Threshold*] The System shall use array sensor waveforms to detect signals based on time periods containing spatially coherent data.

S-1403: [*Threshold*] The System shall automatically generate fk spectra from array station waveform data when a signal detection occurs at an array element.

S-1404: [*Threshold*] The System shall automatically generate a beam for the vector corresponding to the fk spectrum peak for a detection.

S-1406: [*Threshold*] The System shall make separate signal detections for signals arriving at a station for simultaneous arrivals from different directions.

S-1421: [*Threshold*] The System shall store all signal detections.

S-1622: [*Threshold*] The System shall store uncertainties for observed signal detection measurements.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-5573: [*Threshold*] The System shall use the Progressive Multi-Channel Correlation (PMCC) detector to form signal detections on waveforms.

S-5787: [*Threshold*] The System shall create beams steered to the measured azimuth and slowness for all signal detections created for array stations.

S-5969: [*Threshold*] The System shall deconflict detections of the same signal made by multiple detection algorithms.

S-6295: [*Threshold*] The System shall display the detection feature map for an infrasound signal detection.

IDC Specific:
S-5574: [*IDC only, Extensibility*] The System shall use a statistical approach to address the loss of coherence between sensors when performing array signal detection.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Array - A group of stations (sometimes referred to as "elements") deployed with the intent of processing waveform data with specialized techniques exploiting signal coherence between the

stations. This processing improves the signal-to-noise ratio (SNR) and also provides estimates of the direction (azimuth and slowness /velocity) of signals. Arrays are used for seismic, infrasonic, and hydroacoustic monitoring.

Array Coherence - A measure of the similarity of waveforms during a given time interval between the elements of an array. High array coherence indicates that a signal is propagating across the array.

Beam - The product of beamforming; a single derived channel (see channel, derived) representing the sum of the raw channels (see channel, raw) for all the elements of an array.

Beam, Detection - The beam on which a signal detection occurs. When detecting signals for data from an array, a set of beams is formed spanning the regions of monitoring interest. Detectors are run on all of these beams to look for signals. If a signal is detected, the beam on which the detection occurred is known as the detection beam. If there are detections on more than one beam, then the best of these will be selected (e.g., best SNR) as the detection beam.

Beam, fk - A beam steered to point to the maximum fk power spectrum direction (azimuth and slowness) in 2D fk space (see frequency-wavenumber [fk]processing) corresponding to a signal detection on an array. The fk beam should show the best possible signal for a signal detection, and hence is the beam that is automatically shown to an analyst reviewing an event hypothesis.

Channel, Derived - A source for time series data created by processing one or more raw channels (see channel, raw). Examples of common types of processing to form derived channels are filtering (see filter, waveform), beaming (see beamforming [beaming]), and rotation. Derived channels are generally created to enhance the SNR of signals.

Channel, Raw - A source for unprocessed time series data from a seismic, hydroacoustic, or infrasonic sensor (e.g., the output from a short period, vertical component seismometer).

Detection Feature Map - A matrix of values for a particular feature as measured at a particular station over time. The matrix contains a feature vector calculated for each point in time based on the processing of one or more waveforms from the station. The feature vector is a set of values indexed by secondary independent variables, for example, frequency. Detection feature maps are used to detect and identify signals. A spectrogram is an example of a detection feature map where the feature is signal amplitude and the index is frequency. Array coherence is another example where the feature is coherence (or another feature gated by a coherence threshold) and the index is frequency.

Expected Signal Detection - A signal detection that is anticipated to exist but has not been detected by the System. Expected signal detections are typically acquired from empirical knowledge. An Expected Signal Detection is associated with a station, a phase label, and an event hypothesis, and may include an expected waveform and/or a set of signal detection feature measurements. It may also contain information about parameters that were used in the past to detect the signal, such as filter settings, fk parameters, etc. An expected signal detection cannot

become an observed signal detection directly, but can guide the processes that search waveform data for observed signal detections.

F-statistic (Fisher Statistic) - The power on a beam, divided by the average, computed over all the array elements of each element's residual power. The F-statistic can be used as the basis for a signal detector for data from an array or to characterize the coherence of the signal detection on a particular beam. Because each point in a frequency-wavenumber (fk) power spectrum corresponds to an azimuth and slowness pair, calculating an F-statistic for each point in the spectrum can help identify the peaks. See Blandford, "An automatic event detector at the Tonto Forest Seismic Observatory", Geophysics 39, (1974): 633-643.

Pixel Family - A group of adjacent time-frequency vs signal attribute values (attributes can be: azimuth, trace velocity, correlation, etc.) created by progressive muti-channel correlation (PMCC) processing of waveform data from an infrasound array (see Progressive Multi-Channel Correlation [PMCC]). PMCC processing results in spectrogram-type plots (time on the x-axis, frequency on the y-axis, and attributes indicated with a colored pixel), and pixel families represent contiguous regions on the spectrograms. A pixel family is interpreted as indicating the detection of a wave moving across the array.

Power Detector - A signal detector that triggers on changes in waveform amplitude, which is proportional to power. The most well-known of these is the STA/LTA detector (see STA/LTA).

Progressive Multi-Channel Correlation (PMCC) - An array processing technique in which coherency of signals between pairs of sensors within an array is used to detect the presence of a wave propagating across the array. PMCC has proven efficient at detecting low-amplitude, coherent infrasonic signals within incoherent noise. The “progressive” term refers to the idea that the calculation begins with a subnetwork of the array, and progressively adds in more distant sensors to confirm the presence of a wave moving across the entire array. The addition of more distant sensors helps to reject false detections that are not coherent across the entire array, reject sensors with poor degraded quality (high local wind noise or sensor issues), and improves the estimation of parameters for true detections. The PMCC processing is performed consecutively in several frequency bands and in adjacent time windows covering the whole period of analysis.

STA/LTA - A signal detection method that is based on a sudden change in signal power resulting from the onset of a signal. STA/LTA is calculated as a ratio of short-term average (STA) signal power (or energy) to a long-term average (LTA) power (or energy). The STA time window typically precedes the LTA time window. When there is no signal present, hence only noise in both windows, the STA/LTA ratio is ~1. When a signal is present in the STA time window, and noise is present in the LTA time window, the STA/LTA ratio is > 1. A detection is declared when the STA/LTA ratio exceeds a specified threshold.

Signal Detection - A specific interval on a waveform marking the arrival of a signal of interest. Other portions of the waveform are noise.

Signal Detector Threshold - The threshold that determines when a signal detection will be declared for a given data channel for a given signal detection algorithm.

Three Component Station - A seismic station with separate instruments measuring ground motion in three perpendicular directions: up-down, north-south, and east-west. These directions are often referred to as Z, N, and E. Also referred to as a 3C station.

Waveform QC Mask - The tag applied to a segment of waveform data with a QC (see waveform quality control) problem. Each QC mask includes a start and stop time and a description of the type of problem. Subsequent waveform processing algorithms may use this information to mask (i.e., ignore) these segments.

Z-Detector - A signal detection method that statistically estimates the distance of the signal from the mean in units of the standard deviation. The Z Detector produces a constant false alarm rate rather than a constant detection rate and is essentially independent of the noise field behavior. It has the advantage of automatic adjustment to variance in the background noise. If the background variance is small, a small change in input is required for a large change in output. If the background variance is large, a large input change is required for a significant output change.

IDC Specific:
None.

NOTES

General:
1. The System references empirical knowledge from past events and geophysical models to guide in detecting signals.

2. Although this Use Case does not store data, this Use Case maps to storage specifications because it creates data that are stored in other Use Cases. See 'System Detects Event' UC and 'Refines Event' UC.

IDC Specific:
None.

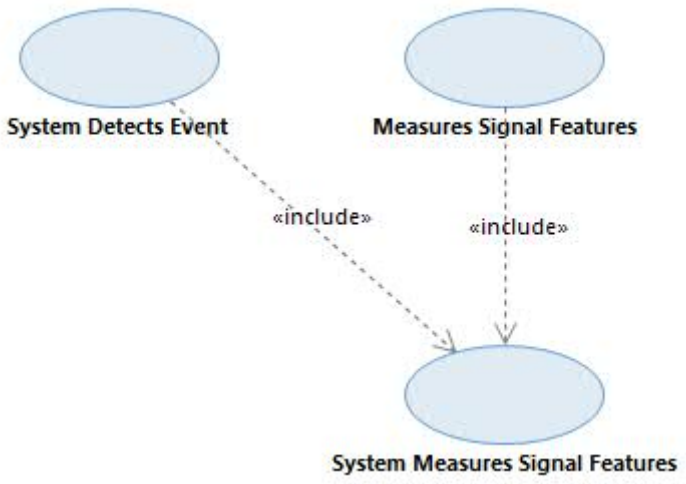
OPEN ISSUES

None.

IDC Use Case Report

UC-02.05 System Measures Signal Features

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the System measures signal detection features on waveform data. Several types of feature measurement are possible depending on the type of station making the detection (seismic, infrasonic, and hydroacoustic). For all types of stations, on a station-by-station basis, the System forms groups of signal detections that correspond to different events. The System measures general time and frequency domain features of signal detections for all types of stations. The System extracts polarization features for 3-component seismic station signal detections. For signal detections from seismic and infrasound array stations, the System measures azimuth and slowness, as well as cepstral features. For hydroacoustic stations, the System makes a variety of specialized time domain, frequency domain, and cepstral domain measurements and groups signal detections from multiple hydrophones at the same station to determine azimuth. For all types of stations, the System assigns preliminary phase labels to signal detections using available signal features.

The System uses default signal detection feature measurement parameters configured by the System Maintainer (see ‘Configures Processing Components’ UC), override parameters set by the Analyst (see 'Measures Signal Features' UC), or parameters derived from earth models or historical processing results to support an iterative, feedback-based processing sequence (see 'System Builds Events using Signal Detections' UC).

ACTOR DESCRIPTIONS

None.

PRECONDITIONS

1. One or more signal detections are available for signal detection feature measurement.

POSTCONDITIONS

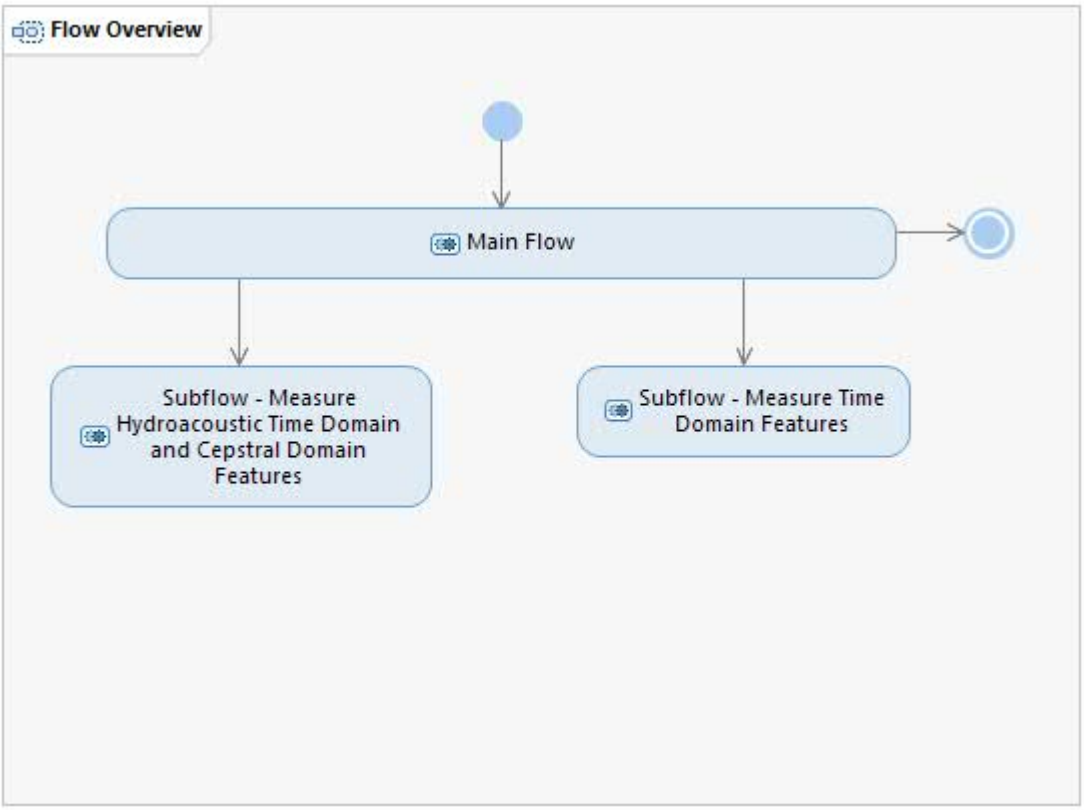
1. The System produces a set of signal detection feature measurements.

2. The System assigns preliminary phase labels to each signal detection.

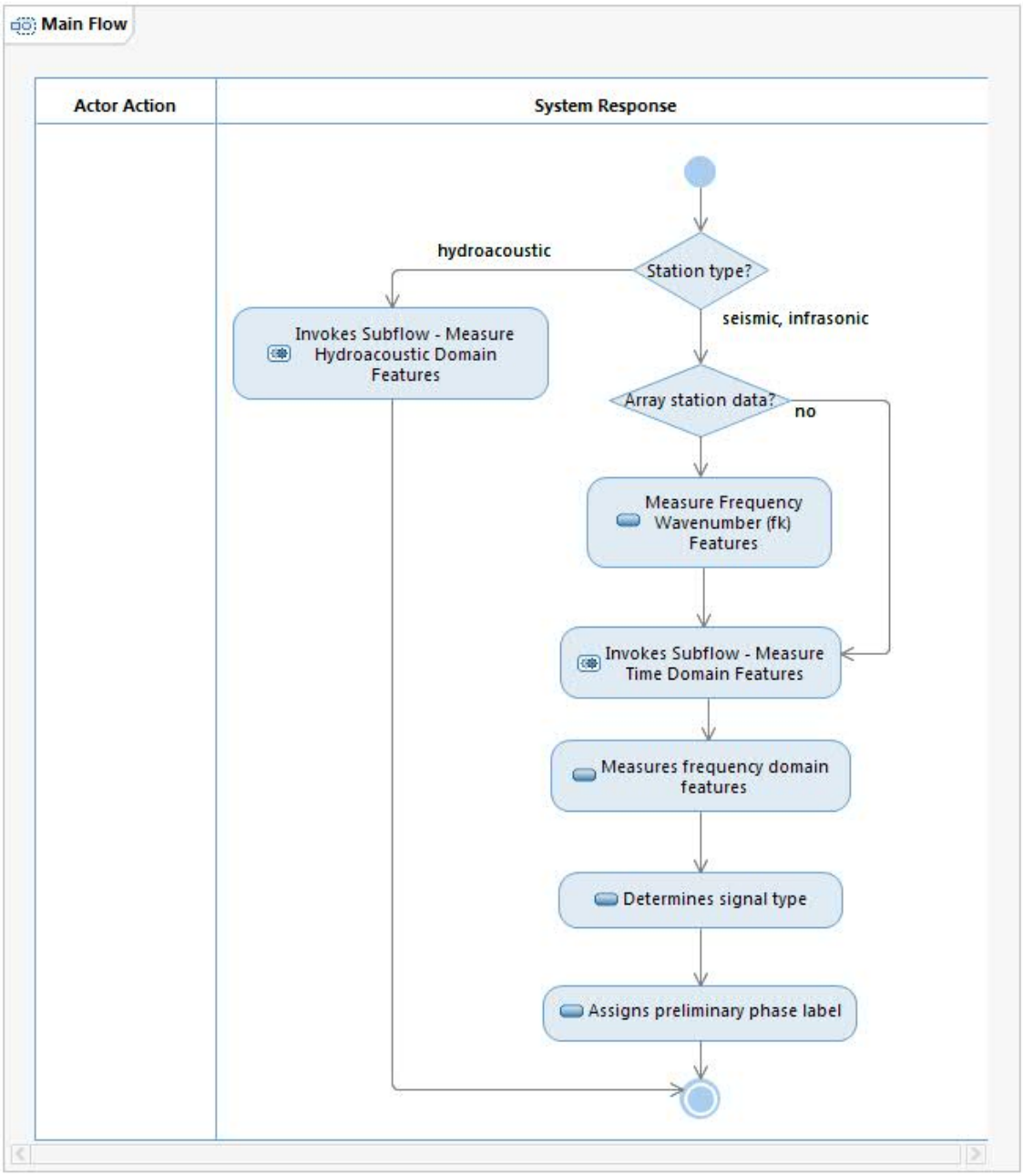
3. The System produces groups of signal detections per station corresponding to distinct events.

ACTIVITY DIAGRAMS

Flow Overview



Main Flow



Action Descriptions

Action: "Measure Frequency Wavenumber (fk) Features"

The System conducts an fk analysis on a detected signal originating from a seismic or infrasonic array station (see 'System Enhances Signals' UC). The System measures the azimuth, slowness, azimuth uncertainty, and slowness uncertainty of the signal detection from the corresponding peak in the fk power spectrum.

Action: "Measures frequency domain features"

The System transforms the detected signal's time-series data originating from either a seismic or infrasonic station into a frequency domain using a Fourier transform. The System measures

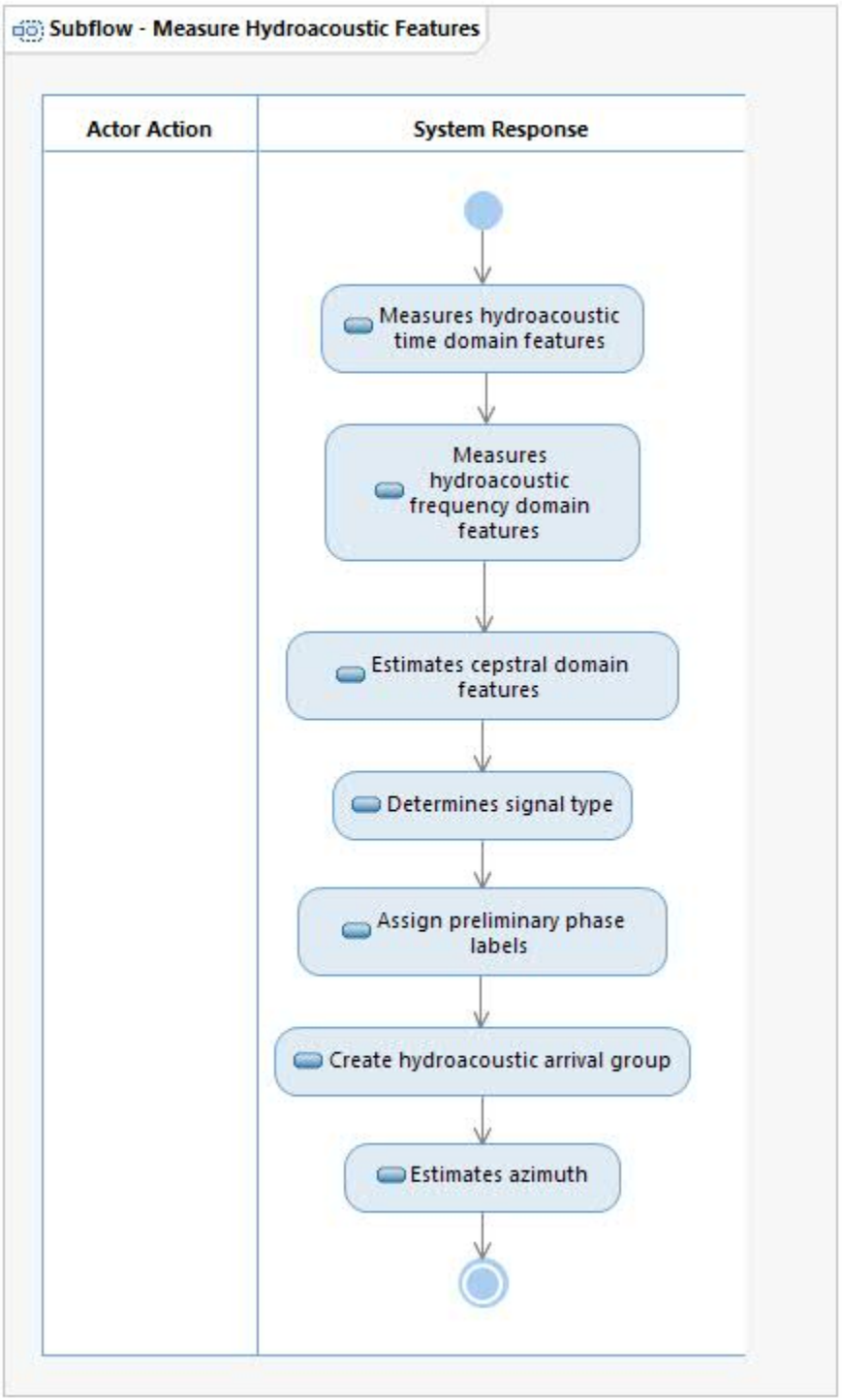
features such as total energy, total power, average power, power spectral density, and signal cepstrum.

Action: "Determines signal type"
The System categorizes the detected seismic signal as one of four initial wave types (teleseismic P, regional P, regional S, or noise) used for grouping signal detections and for phase identification. For a detected signal originating from an array station, the System uses horizontal slowness of the signal and its fk measurement quality to determine signal type. For a detected signal originating from a 3-component station, the System uses the detected signal's general time domain features plus additional polarization features to determine signal type. The System categorizes the detected infrasonic signal as either 'I' or 'N' based on horizontal velocity. The System identifies microbarom signals.

Action: "Assigns preliminary phase label"
The System groups the detected seismic or infrasonic signals into station association groups where each signal detection belongs to a single group. Each group contains signal detections from a single station that are likely signal detections of the same event. The System assigns seismic phase identification such as P, Pg, S, Lg, Px. The System assigns infrasonic phase identification such as I and Ix.

Alternate Flows
1. Any System Action - This use case is invoked by other use cases and may require only parts of this use case to be performed. See the invoking use case for details.

Subflow - Measure Hydroacoustic Features



Action Descriptions

Initial Action

The System uses instrument response information received form the station to perform deconvolution.

Action: "Measures hydroacoustic time domain features"
The System estimates hydroacoustic time domain features on the detected signal originating for either a H- or T-station. The System estimates features, such as signal onset time, signal termination time, and signal summation time, which are used to define boundaries where signal energy is present and the amount of time in which SNR is above a specified threshold. The System estimates other time domain features, such as intensity average time and peak energy and time, signal time spread, signal skewness, signal kurtosis, and number of threshold crossings which are ultimately used to determine signal type. The invoking use case specifies the waveform, measurement time markers, time domain feature parameters, and measurement (i.e., time feature, energy feature, moment feature) in order to measure hydroacoustic time domain features.

Action: "Measures hydroacoustic frequency domain features"
The System transforms the detected signal's time-series data into a frequency domain and measures frequency domain features.

Action: "Estimates cepstral domain features"
The System detects any periodicities in the power spectrum of the detected signal originating from a H- or T-station. The System takes the Fourier transform of the logarithmically scaled power spectrum resulting in a computed cepstrum and a set of parameters characterizing the extracted signal. The System estimates the delay time between pulses from the largest peak in the cepstrum between some minimum and maximum time delay. The System measures the size of the peak relative to the variance in the cepstrum, which provides a measure of the significance of the cepstral peak. The invoking use case specifies the waveform, filters, and cepstral parameters in order to estimate cepstral domain features.

Action: "Determines signal type"
The System uses extracted hydroacoustic time domain features and cepstral domain features and determines signal type (H phase, T phase, or noise) of the detected signal originating from a H- or T-station.

Action: "Assign preliminary phase labels"
For data from each sensor at a hydroacoustic station, the System forms phase sets of detected signals based on signal duration overlap and signal type. The System conducts a time-ordered search for the next non-associated T or H arrival and forms a set generator. The System may associate a subsequent arrival with the generator to form a phase set if the arrival's signal type is similar to the generator and its signal duration is within the duration estimated by the generator. The System evaluates the relative times of each of these sets. As a result, the signal having the largest amplitude is "defining" for that set and is identified as a T- or H-phase depending upon the signal type. Other arrivals in the set are identified as secondary arrivals (Tx or Hx) resulting from continental margin, islands, etc.

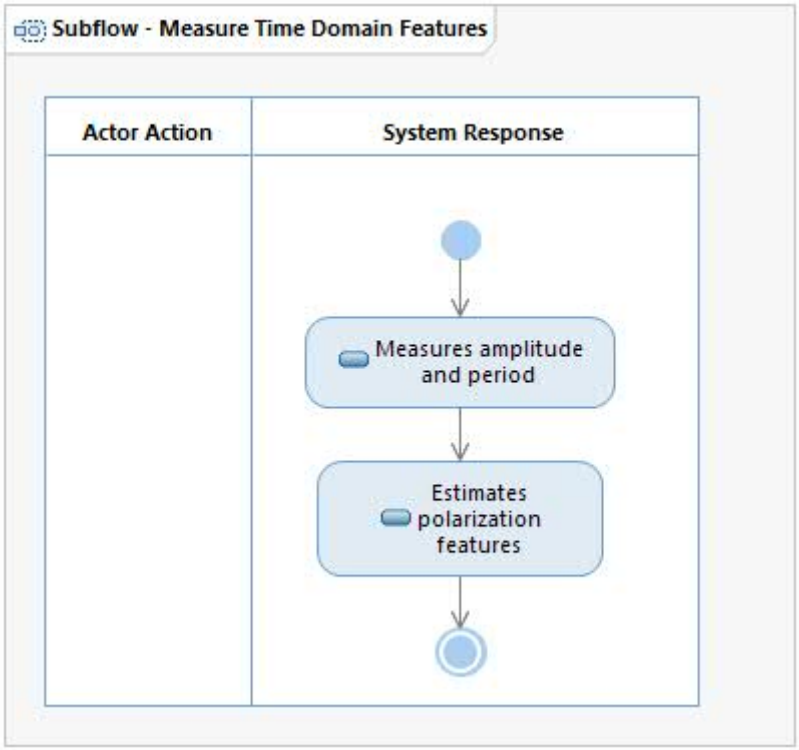
Action: "Create hydroacoustic arrival group"
For H-stations only, the System groups signal detections together from individual hydrophone stations that potentially originate from the same source. The System creates Hydroacoustic

Arrival Groups (HAG) based on maximum delay time for each group and hydroacoustic time domain features for each signal detection.

Action: "Estimates azimuth"
The System estimates azimuth for each Hydroacoustic Arrival Group (HAG) based on the relative timing difference across the sensors.

Alternate Flows
1. Action "Create hydroacoustic arrival group" - The System may use hydroacoustic arrival groups previously created by this flow or by the Analyst (see 'Measures Signal Features' UC) rather than creating new hydroacoustic arrival groups, in which case this action is skipped, and this flow continues.

Subflow - Measure Time Domain Features



Action Descriptions
Action: "Measures amplitude and period"
The System measures amplitude, and period. The invoking use case specifies the type of measurement to make (e.g., A5/2, ALR/2), the signal detection for which the measurement is being made, the waveform to measure, measurement time markers, and selected filter. Additionally, the System needs to convert the amplitude measurement in counts to earth displacement, velocity or acceleration.

Action: "Estimates polarization features"
The System conducts polarization analysis on waveforms originating from 3-component seismic data to estimate polarization features. The System filters the data using a bandpass filter and applies an identical series of overlapping cosine-tapered time windows to the filtered data (see

'System Enhances Signals' UC). The System calculates polarization separately for each window resulting in a variety of features including 3-C amplitude of the signal, signal rectilinearity, planarity, long-axis incidence angle, short-axis incidence angle, horizontal-to-vertical power ratios, maximum-to-minimum ratio of the horizontal components, and azimuth. Implicitly assuming each detection is a P-type phase, the System estimates the angle of incidence of the signal and uses a parameterized phase velocity to derive slowness.

Alternate Flows
None.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1273: [*Threshold*] The System shall select to process waveform data containing a QC Mask based on configured parameters.

S-1326: [*Threshold*] The System shall convert amplitude measurements from measured counts to earth displacement.

S-1425: [*Threshold*] The System shall compute time domain measurements for signal detections.

S-1426: [*Extensibility*] The System software shall provide an extensible architecture for integrating new amplitude algorithms and measurements.

S-1427: [*Threshold*] The System shall compute uncertainties for observed signal detection measurements.

S-1438: [*Threshold*] The System shall store time domain measurements.

S-1441: [*Threshold*] The System shall compute polarization feature measurements.

S-1450: [*Threshold*] The System shall store polarization feature measurements.

S-1453: [*Threshold*] The System shall compute frequency domain waveform measurements.

S-1454: [*Threshold*] The System shall compute the Fourier transform of a waveform.

S-1455: [*Threshold*] The System shall compute the inverse Fourier transform of a waveform.

S-1465: [*Threshold*] The System shall store frequency domain waveform measurements.

S-1469: [*Threshold*] The System shall make fk spectra measurements on fk spectra.

S-1470: [*Threshold*] The System shall normalize array station channels for fk spectra calculations.

S-1471: [*Threshold*] The System shall apply fk space-based filters to fk spectra.

S-1486: [*Threshold*] The System shall store fk spectra measurements.

S-1489: [*Threshold*] The System shall group seismic signal detections from a single station that belong to the same event.

S-1490: [*Threshold*] The System shall use seismic signal detection phase assignment parameters and presumed event hypotheses formed using the seismic signal detection grouping criteria to assign phases to seismic signal detections.

S-1491: [*Threshold*] The System shall support concurrent seismic signal detection grouping criteria.

S-1842: [*Threshold*] The System shall store predicted amplitude attenuation.

S-1843: [*Threshold*] The System shall store predicted amplitude attenuation uncertainties.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2104: [*Threshold*] The System shall calculate power spectral density.

S-2174: [*Threshold*] The System shall generate automated measurements in less than three (3) seconds for an event hypothesis with up to 100 associated signal detections.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-2411: [*Threshold*] The System shall group hydroacoustic signal detections from a single station that belong to the same event (i.e. create hydroacoustic arrival groups).

S-2417: [*Threshold*] The System shall store hydroacoustic signal detection groups

S-5626: [*Threshold*] The System shall support concurrent hydroacoustic signal detections grouping criteria.

S-5631: [*Threshold*] The System shall convert amplitude measurements from measured counts to velocity.

S-5632: [*Threshold*] The System shall convert amplitude measurements from measured counts to acceleration.

S-5633: [*Threshold*] The System shall group infrasonic signal detections from a single station that belong to the same event.

S-5634: [*Threshold*] The System shall support concurrent infrasound signal detection grouping criteria

S-5641: [*Objective / Priority 1*] The System shall identify microbarom signals.

S-5644: [*Threshold*] The System shall use hydroacoustic signal detection phase assignment parameters and presumed event hypotheses formed using the hydroacoustic signal detection grouping criteria to assign phases to hydroacoustic signal detections.

S-5647: [*Threshold*] The System shall use infrasonic signal detection phase assignment parameters and presumed event hypotheses formed using the infrasonic signal detection grouping criteria to assign phases to infrasonic signal detections.

S-5722: [*Threshold*] The System shall store power spectral density.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Cepstral Domain Measurements - Measurements made in the cepstral domain for characterizing a signal of interest, in particular, hydroacoustic signals. The cepstral domain highlights periodicities in the spectrum (frequency domain). A cepstrum of a waveform is the Fourier transform of the waveform's power spectrum. The independent variable of the cepstrum is called quefrency, expressed in units of time, but representing the period of harmonic features of the waveform.

Frequency Domain Measurements - Measurements made in the frequency domain for characterizing a signal of interest, including: total energy, total power, average power, power spectral density, and signal cepstrum. A segment of waveform data (a time-series) is transformed to the frequency domain using a Fourier transform.

Frequency-Wavenumber (fk) Measurements - Measurements made from the fk transformed data (see frequency-wavenumber [fk] processing) of an array: azimuth, azimuth uncertainty, slowness, slowness uncertainty, and array coherence.

Frequency-Wavenumber (fk) Power Spectrum - The representation in the frequency-wavenumber domain of coherent signal power in the waveform data from an array for a specified time interval. Calculation of fk power spectrum requires three Fourier transforms to convert time-sampling to frequency (designated by f), and longitude and latitude sampling to x and y wavenumbers (designated by k). Typically, fk power spectra are represented as 2D plots (not 3D), by collapsing the frequency information to a single value for each x and y slowness, by averaging values across the range of frequencies.

Frequency-Wavenumber (fk) Processing - A signal processing technique that can be applied to a short interval of waveform data from an array to determine if a signal is present and estimate the signal's azimuth and slowness. Waveform data are first converted to a frequency-wavenumber power spectrum and then further processing is done in the fk domain.

Hydroacoustic Arrival Group (HAG) - A group of signal detections on different hydrophones from a single hydroacoustic station that have been determined to come from the same event and that can be used to determine azimuth back to the event. HAGs can only be formed for multiple element (array) stations, and hence apply to H stations, but not T stations.

Hydroacoustic Time Domain Measurements - Measurements made directly on waveforms from hydroacoustic sensors, including: signal termination time, signal summation time, signal time spread, signal skewness, signal kurtosis, peak energy in a defined time period, intensity average time in a defined time period, peak energy in a defined time period, and crossing counts (the number of times a waveform crosses a threshold in a defined time period).

Phase Grouping - The process of grouping all of the signal detections from one station that are assumed to come from the same event. Each signal represents a different phase. The system bases grouping on signal detection measurements (e.g., relative timing, azimuth, slowness). Various operations can be made on signal detections after placing them in groups, including phase assignment, and creation of a single station event hypothesis.

Polarization Features - Features derived from the analysis of three component data (see three component station) that characterize how a signal has been partitioned across the components. Polarization features can be used to identify phase type and for association with an event hypothesis. Polarization features include: azimuth, azimuth uncertainty, slowness, slowness uncertainty, rectilinearity, planarity, horizontal-to-vertical power ratio, and short and long axis incidence angles.

Preliminary Phase Label - A seismic phase label determined using only station signal detection feature measurements (i.e., prior to network signal association). The possible preliminary phase labels are: compressional (P), shear (S), teleseismic (Tx), regional (Rx), and noise (N).

Signal Characterization - The process of measuring signal detection features for the purpose of determining the phase of a signal detection, and for determining whether or not a signal detection is consistent with an event hypothesis (see signal association).

Signal Detection - A specific interval on a waveform marking the arrival of a signal of interest. Other portions of the waveform are noise.

Signal Detection Feature - A feature associated with a signal detection (e.g., arrival time, back azimuth, horizontal slowness, amplitude, frequency content).

Signal Detection Feature Measurement - A measurement of a signal detection feature, including measurement uncertainty.

Three Component Station - A seismic station with separate instruments measuring ground motion in three perpendicular directions: up-down, north-south, and east-west. These directions are often referred to as Z, N, and E. Also referred to as a 3C station.

Time Domain Measurements - Measurements made directly on time-series data (i.e., waveforms). Examples of general time domain measurements include onset time, amplitude, and period.

IDC Specific:
None.

NOTES

General:
1. T-stations have three components. However, only the vertical component's waveform data are processed. The horizontal components are generally noisy because of coastal location. As a result, there are no estimates of azimuth and slowness for T-station arrivals.

2. Hydroacoustic time domain features are estimated for both H-station and T-station data.

3. There will be two azimuth estimates for HAGs originating from only two stations.

4. The System references empirical knowledge from past events and geophysical models to guide in measuring signal features.

5. Although this Use Case does not store data, this Use Case maps to storage specifications because it creates data that are stored in other Use Cases. See 'System Detects Event' UC and 'Refines Event' UC.

IDC Specific:
None.

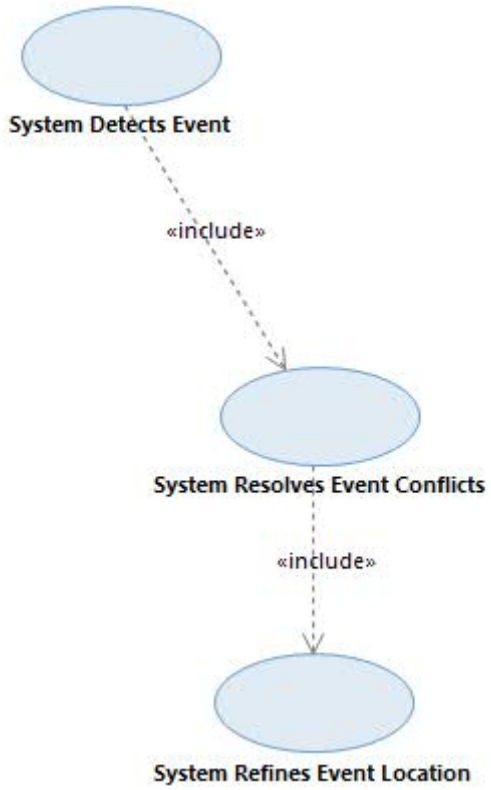
OPEN ISSUES

None.

IDC Use Case Report

UC-02.07 System Resolves Event Conflicts

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the System uses conflict resolution to reconcile event hypotheses built by multiple association processes (see ‘System Detects Events Using Waveform Correlation’ UC and ‘System Builds Events Using Signal Detection’ UC). During conflict resolution the System forces signal detections to be associated to at most one event hypothesis, corrects erroneously associated signal detections, and merges duplicate event hypotheses. The System verifies all event hypotheses formed or modified during conflict resolution meet the event hypothesis formation criteria (see ‘System Builds Events Using Signal Detection’ UC) configured by the System Maintainer (see 'Configures Processing Components' UC). The System stores full provenance data, including for events that are discarded by this use case.

ACTOR DESCRIPTIONS

None.

PRECONDITIONS

None.

POSTCONDITIONS

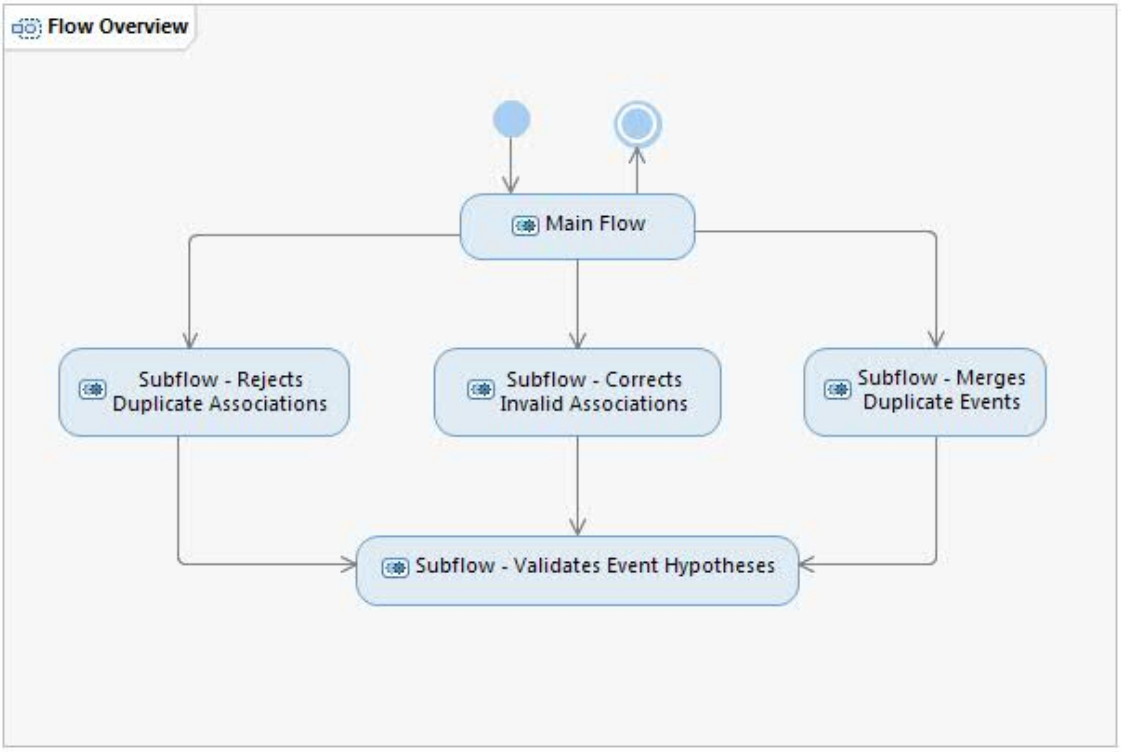
1. This use case produces a set of one or more event hypotheses. The event hypotheses in this set have no event conflicts.

2. The System calculates an event hypothesis quality metric for each event hypothesis produced by this use case.

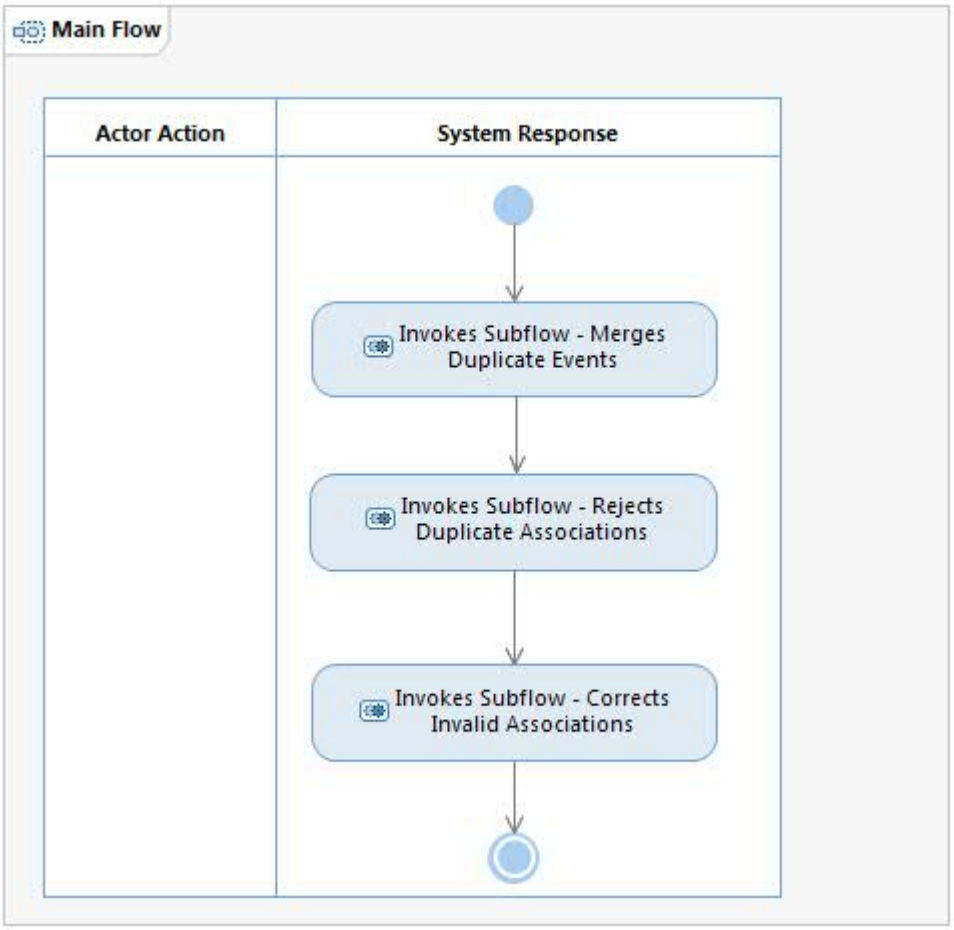
3. This use case produces a set of zero or more unassociated signal detections. The System unassociated the signal detections in this set from one or more event hypotheses without associating them to a new event hypothesis.

ACTIVITY DIAGRAMS

Flow Overview



Main Flow



Action Descriptions

Action: "Invokes Subflow - Merges Duplicate Events"

The System merges duplicate of split event hypotheses.

Action: "Invokes Subflow - Rejects Duplicate Associations"

The System updates associations so that each signal detection is associated to at most one event hypothesis.

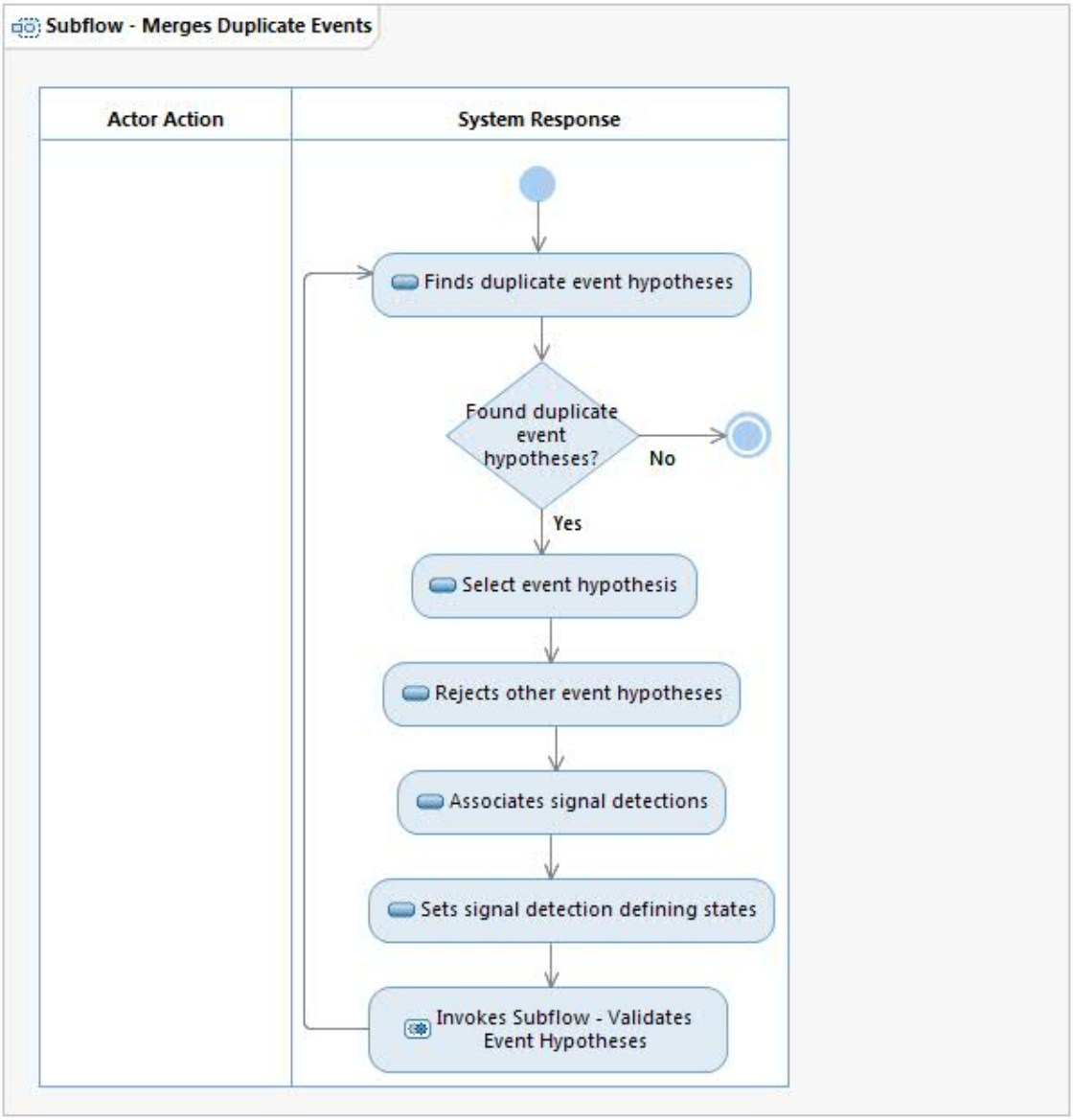
Action: "Invokes Subflow - Corrects Invalid Associations"

The System updates associations so that each signal detection is associated to the most likely event hypothesis. This includes correcting associations to mixed event hypotheses (i.e., corrects situations where signal detections from multiple events have been erroneously associated to a single event), and split event hypotheses (i.e., corrects situations where signal detections that should have been associated to a single event have been erroneously associated to multiple events). The System may produce unassociated signal detections if it determines signal detections are not likely to be associated to any of the event hypotheses.

Alternate Flows

1. Initial Action - If an Analyst is actively reviewing any of the event hypotheses the System would process in this use case, those event hypotheses are disregarded from the remainder of this use case, and this use case continues.

Subflow - Merges Duplicate Events



Action Descriptions

Action: "Finds duplicate event hypotheses"

The System uses the distance between event hypothesis locations and a spatiotemporal distance threshold to find two or more event hypotheses in the conflict resolution set that actually represent a single event. The System Maintainer configures this threshold (see 'Configures Processing Components' UC) and the Analyst has the option to select the threshold (see 'Builds Event' UC).

Action: "Select event hypothesis"

The System selects one of the duplicate event hypotheses to keep while rejecting the others. The System selects the event hypothesis to keep based on the algorithm that built or detected each event hypothesis (e.g., event hypotheses detected with waveform correlation might be preferred over event hypotheses built using signal detection association), the processing stage that built each event hypothesis, etc. The System Maintainer configures the criteria used to select an event hypothesis (see 'Configures Processing Components' UC). The Analyst has the option to select values for the criteria (see 'Builds Event' UC).

Action: "Associates signal detections"
The System associates to the selected event hypothesis the signal detections associated to the rejected event hypotheses and assigns phase labels to those signal detections (see 'System Predicts Signal Features' UC). The System uses the single station and network signal association parameters to find which of these signal detections associate to the event hypothesis. The System leaves unassociated signal detections that do not correctly associate to the selected event hypothesis. The System will not reassociate a signal detection to an event hypothesis if an Analyst has previously unassociated that signal detection from that event hypothesis.

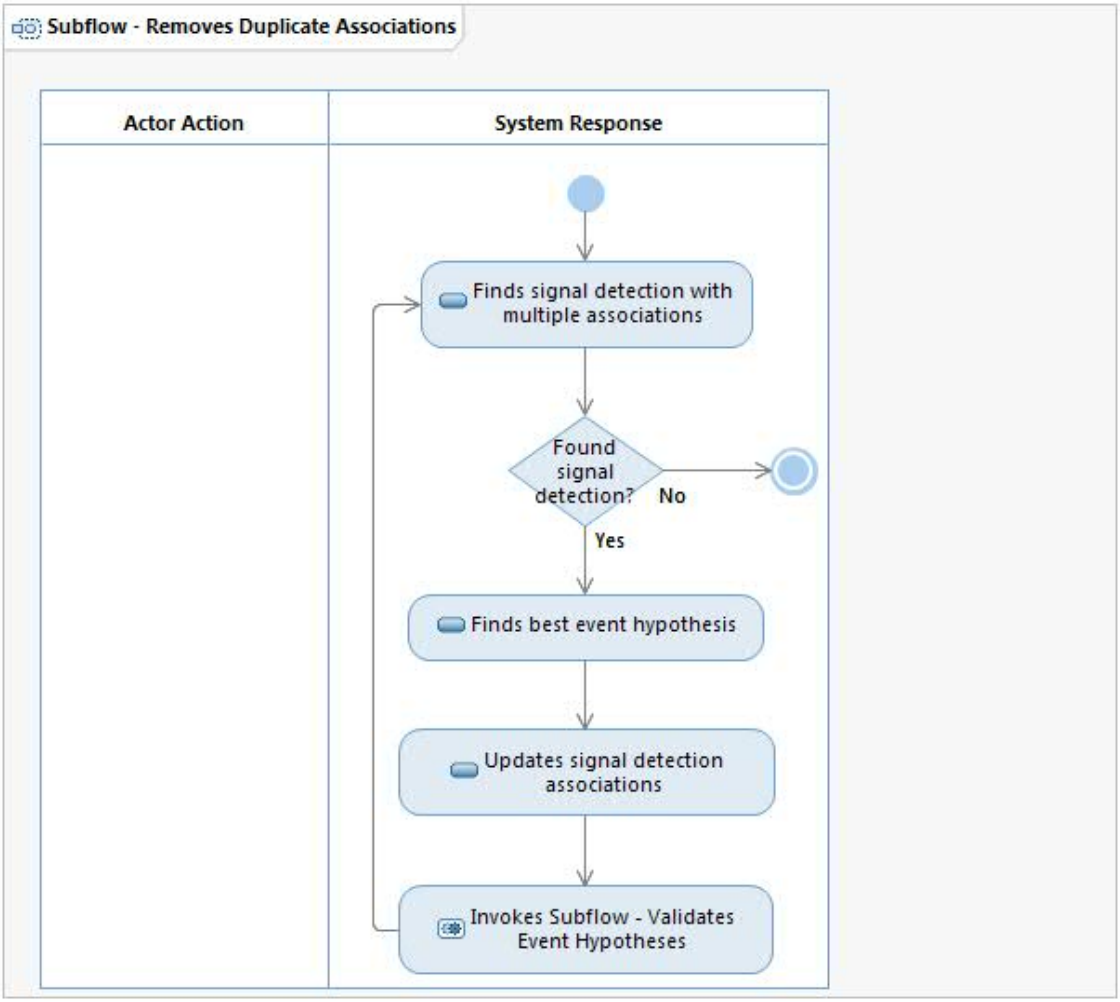
The System Maintainer configures the default signal detection association parameters and phase assignment criteria (see 'Configures Processing Components' UC). The Analyst has the option to select values for these parameters (see 'Builds Event' UC).

Action: "Sets signal detection defining states"
The System sets the newly associated signal detection's feature measurement defining states for event hypothesis location, event hypothesis magnitude estimation, and discriminant calculations. The System Maintainer configures the criteria used to determine if signal detection feature measurements are defining or non-defining for individual calculations (see 'Configures Processing Components' UC).

Action: "Invokes Subflow - Validates Event Hypotheses"
The System validates the selected event hypothesis.

Alternate Flows
None.

Subflow - Rejects Duplicate Associations



Action Descriptions

Action: "Finds signal detection with multiple associations"

The System finds a signal detection associated to more than one event hypothesis in the conflict resolution set.

Action: "Finds best event hypothesis"

The System uses the single station and network signal detection association parameters, the event hypothesis quality statistics, and the event hypothesis quality metric to find the event hypothesis most likely associated to the signal detection. The System Maintainer configures these parameters (see 'Configures Processing Components' UC). The Analyst has the option to select values for these parameters (see 'Builds Event' UC).

Action: "Updates signal detection associations"

The System updates the signal detection's associations so it is only associated to the most likely event hypothesis.

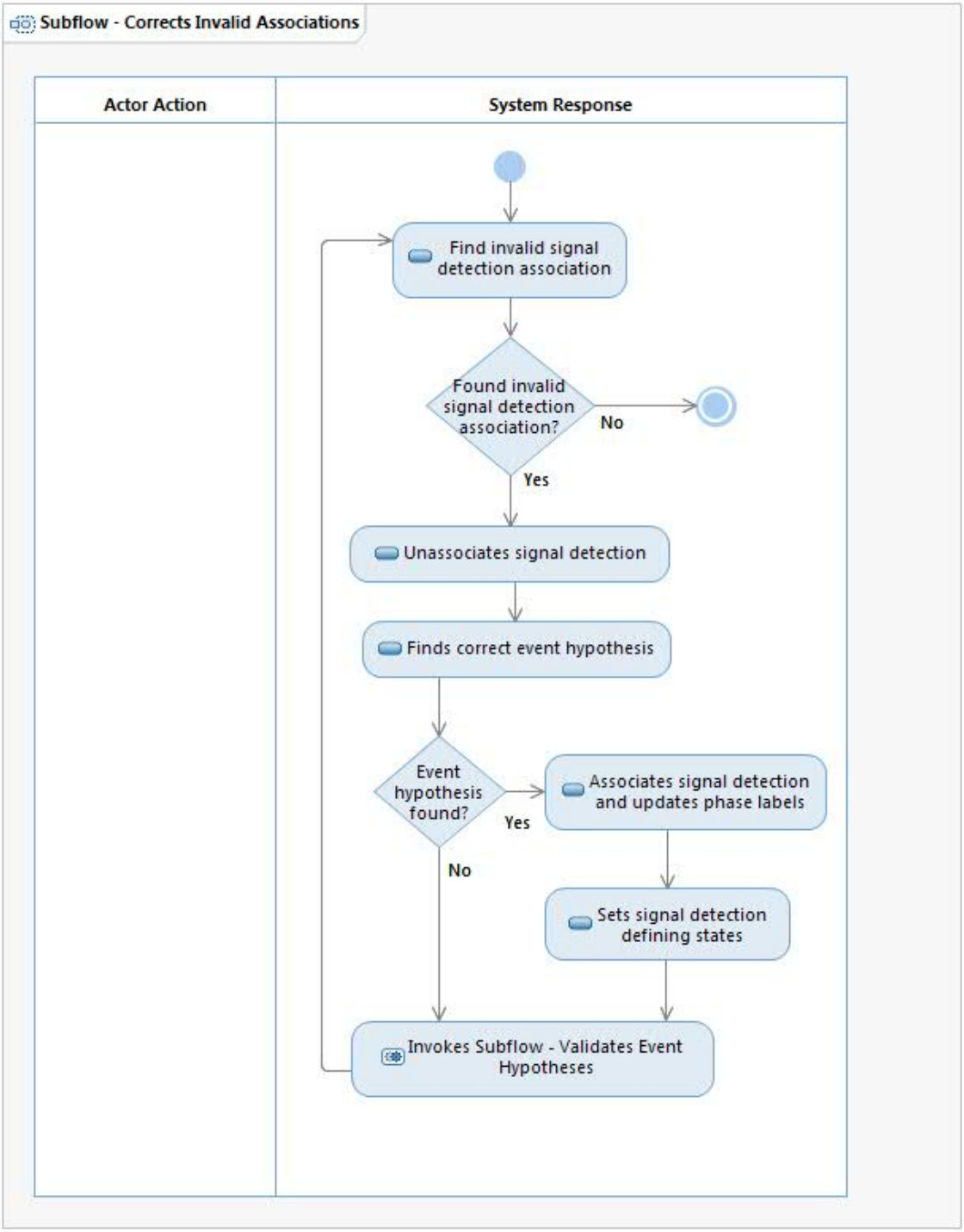
Action: "Invokes Subflow - Validates Event Hypotheses"

The System validates each event hypothesis that was modified by updating the signal detection's associations.

Alternate Flows

1. Action "Finds best event hypothesis" - since the “Validates Event Hypotheses” subflow relocates and potentially rejects the event hypotheses processed in this flow, it is possible for the System to determine the signal detection does not associate well with any of the event hypotheses in the conflict resolution set. If this occurs, the System unassociates the signal detection from all event hypotheses, and flow continues with Action "Invokes Subflow - Validates Event Hypotheses".

Subflow - Corrects Invalid Associations



Action Descriptions

Action: "Find invalid signal detection association"

The System uses the single station and network signal detection association parameters to find a signal detection incorrectly associated (e.g., due to large feature measurement residuals) to one of the event hypotheses in the conflict resolution set. Signal detection associations that were valid when the System first made the association may become invalid during this use cases since

the subflows modify signal detection associations and the “Validates Event Hypotheses” subflow relocates event hypotheses. The System Maintainer configures the signal detection association parameters (see 'Configures Processing Components' UC). The Analyst has the option to select values for these parameters (see 'Builds Event' UC).

Action: "Unassociates signal detection"
The System unassociates the invalid signal detection from the event hypothesis.

Action: "Finds correct event hypothesis"
The System uses the single station and network signal association parameters, the event hypothesis quality statistics, and the event hypothesis quality metrics to find the event hypothesis in the remainder of the conflict resolution set most likely to have an association to the signal detection. The System will not associate the signal detection to an event hypothesis when an Analyst has previously unassociated that signal detection from that event hypothesis.

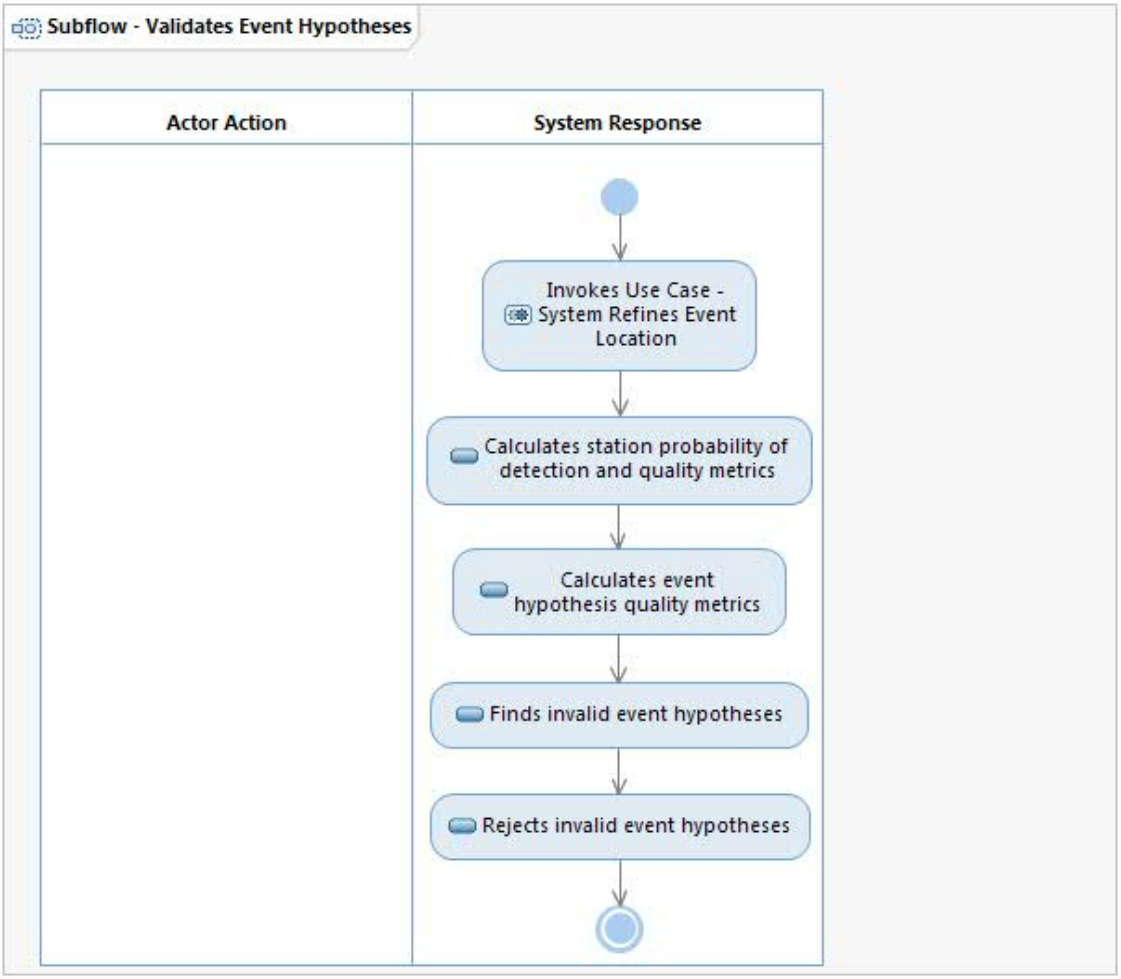
Action: "Associates signal detection and updates phase labels"
The System associates the signal detection to the selected event hypothesis and assigns the signal detection the most appropriate phase label for that event hypothesis. The System also updates phase labels for other signal detections associated to the event hypothesis if they have the potential to change due to the new signal detection association (e.g., update phase labels to account for relative phase arrival times at a station).

Action: "Sets signal detection defining states"
The System sets the newly associated signal detection's feature measurement defining states for event hypothesis location, event hypothesis magnitude estimation, and discriminant calculations. The System Maintainer configures the criteria used to determine if signal detection feature measurements are defining or non-defining for individual calculations (see 'Configures Processing Components' UC).

Action: "Invokes Subflow - Validates Event Hypotheses"
The System validates the event hypotheses modified in this flow.

Alternate Flows
None.

Subflow - Validates Event Hypotheses



Action Descriptions

Initial Action

This flow operates on an event hypothesis set provided by the invoking flow. The event hypothesis set contains one or more event hypotheses.

Action: "Invokes Use Case - System Refines Event Location"

The System relocates each event hypothesis from the event hypothesis set that has had one or more signal detections with a location defining feature measurement associated to it or unassociated from it by the invoking subflow.

Action: "Calculates station probability of detection and quality metrics"

The System computes the station quality metric for configured raw and derived channels. The System computes each station's probability of detection for each location solution of each event hypothesis from the station quality metrics. The System Maintainer configures the station probability of detection parameters (see 'Configures Processing Components' UC)

Action: "Calculates event hypothesis quality metrics"

The System calculates a quality metric for each location solution of each event hypothesis in the event hypothesis set. The System Maintainer configures event hypothesis quality metric parameters (see 'Configures Processing Components' UC).

Action: "Finds invalid event hypotheses"
The System marks as invalid any event hypotheses that do not satisfy the previously configured event hypothesis formation criteria, which have event hypothesis quality metrics below the previously configured threshold or which are the same as event hypotheses previously rejected in Analyst review. The System does not mark as invalid any Analyst created event hypotheses.

The System Maintainer configures the event hypothesis formation criteria, the event hypothesis quality metric thresholds, and the parameters defining what makes two event hypotheses the same (see 'Configures Processing Components' UC). The Analyst has the option to select values for parameters (see 'Builds Event' UC).

Action: "Rejects invalid event hypotheses"
The System unassociates all signal detections from the invalid event hypotheses and marks the event hypotheses as rejected.

Alternate Flows
None.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1504: [*Threshold*] The System shall use the seismic, hydroacoustic, and infrasound network signal association parameters to form event hypotheses from any combination of seismic, hydroacoustic, and infrasound signal detections meeting the signal association event hypothesis formation criteria.

S-1505: [*Threshold*] The System shall use empirical values of the network signal association parameters during event hypothesis formation.

S-1506: [*Threshold*] The System shall use historic probability of signal detection during event hypothesis formation.

S-1507: [*Threshold*] The System shall use seismic network signal association parameters to assign phases to seismic signal detections.

S-1508: [*Threshold*] The System shall use hydroacoustic network signal association parameters to assign H phases to hydroacoustic signal detections at hydrophone stations.

S-1509: [*Threshold*] The System shall use hydroacoustic network signal association parameters to assign T phases to hydroacoustic signal detections from T-phase stations.

S-1510: [*Threshold*] The System shall use infrasound network signal association parameters to assign phases to infrasound signal detections.

S-1511: [*Threshold*] The System shall support concurrent signal association event hypothesis formation criteria.

S-1512: [*Threshold*] The System shall merge event hypotheses created using different event formation algorithms.

S-1513: [*Threshold*] The System shall associate unassociated signal detections created by any signal detection algorithm to event hypotheses formed by any event formation algorithm.

S-1514: [*Threshold*] The System shall compute the station probability of detecting an event hypothesis during event formation.

S-1515: [*Threshold*] The System shall use variable resolution representations of the Earth for signal association parameter predictions during signal association to account for the varying ability to resolve signals originating in different areas.

S-1516: [*Objective / Priority 2*] The System shall create new event hypotheses which modify existing user-reviewed event hypotheses only when the event quality metric for the automatic event hypothesis improves more than a configured threshold.

S-1518: [*Threshold*] The System shall use the configured earth model(s) during signal detection association.

S-1542: [*Threshold*] The System shall not automatically perform network signal association affecting signal detections that the Analyst is actively reviewing.

S-1543: [*Threshold*] The System shall set signal detections to non-defining for event hypothesis location calculations when the System automatically associates them to Analyst reviewed event hypotheses.

S-1544: [*Threshold*] The System shall set station magnitudes to non-defining for event hypothesis magnitude calculations when the System automatically associates them to Analyst reviewed event hypotheses.

S-1547: [*Threshold*] The System shall recreate an event hypothesis during late association that was rejected in user review only when the event quality metric for the automatic event hypothesis improves more than a configured threshold or when the new event hypothesis definition differs from the original event hypothesis more than a configurable threshold.

S-1548: [*Threshold*] The System shall not automatically reassociate a signal detection to an event hypothesis if an Analyst has previously unassociated that signal detection from the event hypothesis.

S-1567: [*Threshold*] The System shall use the seismic, hydroacoustic, and infrasound network signal association parameters and the signal association event hypothesis formation criteria to resolve situations where the same signal detection is associated to more than one event hypothesis by reassociating the signal detection to at most one event hypothesis.

S-1568: [*Threshold*] The System shall use the seismic, hydroacoustic, and infrasound network signal association parameters and the signal association event hypothesis formation criteria to merge redundant event hypotheses.

S-1569: [*Threshold*] The System shall use the seismic, hydroacoustic, and infrasound network signal association parameters and the signal association event hypothesis formation criteria to correct erroneously associated signal detections.

S-1572: [*Threshold*] The System shall compute the station quality metric for all events.

S-1576: [*Threshold*] The System shall store the station quality metrics for all stations for each event hypothesis.

S-1579: [*Threshold*] The System shall compute an event hypothesis quality metric using the event hypothesis quality statistics for each event hypothesis formed on the System.

S-1580: [*Threshold*] The System shall recompute the event hypothesis quality metric for an event hypothesis when any of the event hypothesis quality statistics used to calculate the event hypothesis quality metric are updated.

S-1581: [*Threshold*] The System shall not automatically form event hypotheses with event hypothesis quality metrics below the event hypothesis quality metric threshold.

S-1582: [*Threshold*] The System shall not screen any Analyst created event hypotheses by their event hypothesis quality metrics.

S-1588: [*Threshold*] The System shall store the event quality metric for each event hypothesis.

S-1597: [*Threshold*] The System shall compute new event hypothesis relocations when an automatic process associates a new location defining signal detection to that event hypothesis.

S-1598: [*Threshold*] The System shall compute new event hypothesis relocations when an automatic process unassociates a location defining signal detection from that event hypothesis.

S-2036: [*Threshold*] The System shall use configured default defining/non-defining state settings and precedence rules to determine the initial defining/non-defining state for each parameter.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-5596: [*Threshold*] The System shall use station-to-event distance when associating signal detections to events.

S-5597: [*Threshold*] The System shall use event magnitude when associating signal detections to events.

S-5598: [*Threshold*] The System shall use waveform data quality when associating signal detections to events.

S-5599: [*Threshold*] The System shall use station noise level when associating signal detections to events.

S-5600: [*Threshold*] The System shall use event location to assign phase identifications to signal detections based on predicted phase ID matching.

S-5601: [*Threshold*] The System shall use event location to assign phase identifications to signal detections based on available empirical phase ID matching.

S-5641: [*Objective / Priority 1*] The System shall identify microbarom signals.

S-5642: [*Objective / Priority 1*] The System shall prevent association of microbarom signals to events.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Association - See signal association.

Defining/Non-Defining - Any observation that contributes to the determination of an event attribute is considered to be "defining" for that attribute. The detection of an event, the location of an event (see event location), the magnitude of an event (see event magnitude, network), and the source type assigned to an event are all determined by specific types of defining observations (travel time, azimuth, slowness, amplitude) from one or more phases recorded by one or more stations. If an observation is linked to an event (associated), but does not contribute to the calculation of an event attribute, then it is considered to be non-defining for that attribute.

Event Hypothesis - A proposed solution for an Event. Each event consists of a sequence of event hypotheses that describe an evolution to a final best model of the event. Each event hypothesis is composed of a set of associated signal detections and has one or more event hypothesis location solutions, one of which must be designated as preferred.

Event Location - The combination of an event's spatial location (see event hypocenter), temporal location, spatial location uncertainty, and temporal location uncertainty.

Event Quality Metric - A quality metric computed as a number in the closed interval [0.0, 1.0] (low to high) for each event hypothesis formed on the System. This metric indicates the quality of the event hypothesis as a function of the event hypothesis's associated signal detections and related measurements, location solution, station state-of-health, and network state-of-health information. The System computes a new event quality metric whenever any parameter used for calculating the metric is updated and stored.

Processing Stage - A named group of data processing and analysis functions, used to track status of increments of work performed on time intervals and events through the System. The flow of data through the System, from data acquisition, through automated processing and multiple reviews, to reporting of an event, is defined as a series of processing stages (e.g., Pipeline, traditional analysis roles). A processing stage may define automatic sequences (see processing sequences), interactive-only activities, or interactive and automatic sequences. A stage description includes a list of functions that are performed, entry criteria (time, event, or data availability triggers), and exit criteria (completion of processing, recognition of an important event, or declaration by an Analyst).

Rejected Event Hypothesis - An event hypothesis determined to be invalid by either the System or an Analyst. The history of rejected event hypotheses, including signal detection associations, are available on the System, and rejected event hypotheses can be reopened by Analysts. All signal detections are unassociated from an event hypothesis when it is rejected, making those signal detections available to form other event hypotheses.

Signal Association - The process of linking (associating) a set of signal detections from a network of stations to an event hypothesis, either existing or new. Association is based on consistency of observed and predicted signal detection feature measurements (e.g., arrival time, azimuth, slowness). Signal association can be done automatically by the system (see pipeline processing), or manually by an analyst.

Signal Detection - A specific interval on a waveform marking the arrival of a signal of interest. Other portions of the waveform are noise.

Signal Detection Feature Measurement - A measurement of a signal detection feature, including measurement uncertainty.

Signal Detection Feature Prediction - A prediction of a signal detection feature, including prediction uncertainty.

IDC Specific:
None.

NOTES

General:

1. The System may only change the signal detections associated to Analyst reviewed event hypotheses if the System's change results in an event hypothesis with high event quality. To determine when this situation occurs, the System checks if any signal detection previously reviewed by an Analyst is no longer associated to the same event hypothesis it was associated to during the Analyst review. If the System finds any such signal detection, the System compares the quality metric of the event hypothesis the signal detection is now associated to with what the event hypothesis's quality metric would be without the signal detection association. If the version of the event hypothesis with the Analyst reviewed signal detection has an event hypothesis quality metric greater than a previously configured threshold over the version without the signal detection, then the event hypothesis is allowed to keep the signal detection. Otherwise the System returns the signal detection association to the Analyst reviewed event hypothesis. The System Maintainer configures this threshold (see 'Configures Processing Components' UC). The System revalidates any event hypotheses modified by this process using "Subflow - Validates Event Hypotheses".

2. "The System uses signal detection feature measurements (see 'System Measures Signal Features' UC) for the signal detections and expected observations of the event hypothesis based on empirical knowledge from past events and geophysical models based parameters to determine the most likely phase for the signal detection and assign phase labels (see 'System Predicts Signal Features' UC). The System Maintainer configures the default phase assignment criteria (see 'Configures Processing Components' UC). The Analyst has the option to select values for these parameters (see 'Builds Event' UC).

3. The subflows in this use case reject event hypotheses as they become invalid by invoking "Subflow - Validates Event Hypotheses." If one subflow invalidates an event hypothesis that would have been made valid by a later subflow, that event hypothesis is still rejected.

4. The conflict resolution set processed in this use case may contain Analyst reviewed event hypotheses. Subject to the constraints discussed in the mapped specifications and use case actions, the System is allowed to modify these Analyst reviewed event hypotheses to resolve event conflicts. The System Maintainer configures based on Analyst processing stage which Analyst reviewed event hypotheses can be included in the conflict resolution set (see 'Configures Processing Components' UC).

5. If an Analyst is actively reviewing a signal detection, the System will not automatically update that signal detection's associations to event hypotheses.

6. Although this Use Case does not store data, this Use Case maps to storage specifications because it creates data that is stored in other Use Cases. See 'System Detects Event' UC and 'Refines Event' UC.

7. The System sets default defining states based on rules previously configured by the System Maintainer (see 'Configures Processing Components' UC).

8. The order of the steps in the Main Flow is notional. The sequence of actions is determined by the 'Defines Processing Sequence' UC.

IDC Specific:
None.

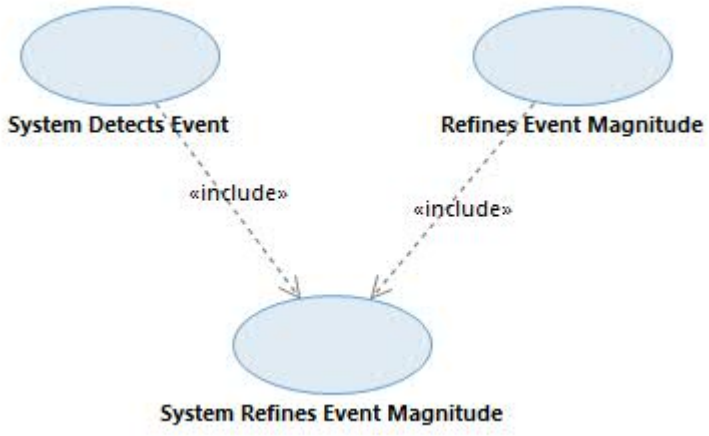
OPEN ISSUES

None.

IDC Use Case Report

UC-02.09 System Refines Event Magnitude

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the System estimates event hypothesis magnitudes. The System determines magnitude as a function of amplitude measurements at detecting and non-detecting stations (see 'System Measures Signal Features' UC), event hypothesis to station distances, and knowledge of the Earth structure (e.g., signal attenuation factors and geometric spreading).

ACTOR DESCRIPTIONS

None.

PRECONDITIONS

1. An event hypothesis is available for magnitude estimation.

2. The event hypothesis location solution to use during magnitude estimation is specified as an input to this use case.

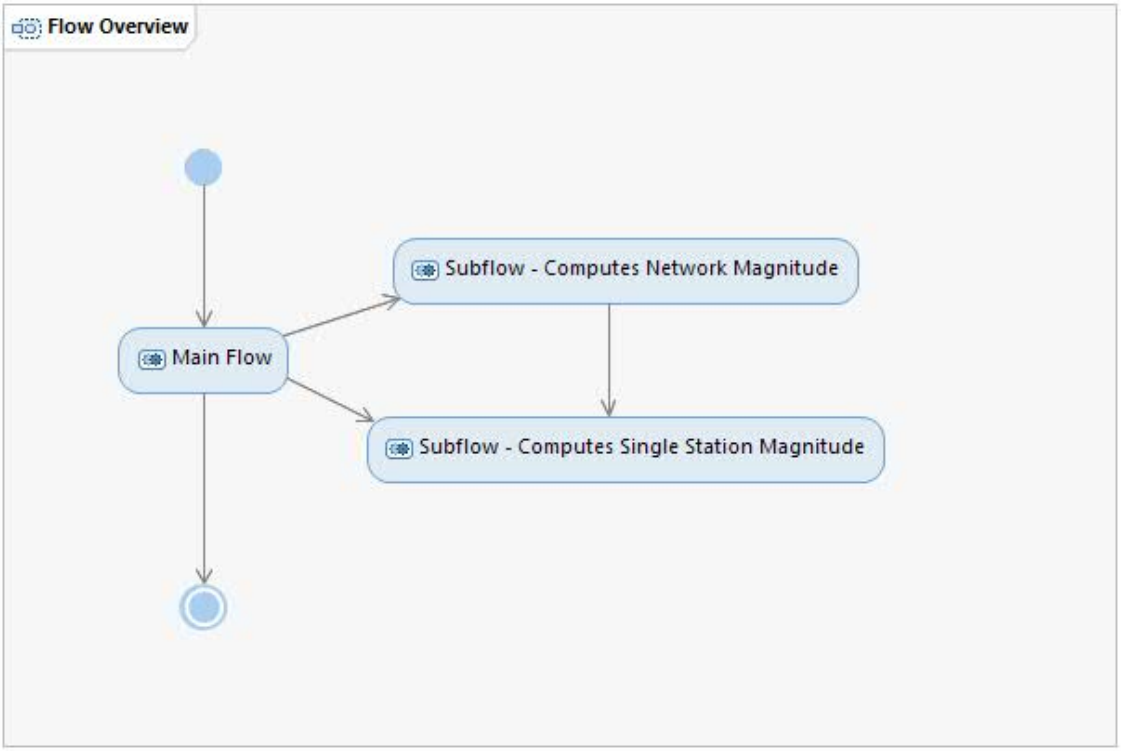
3. Any signal detection features (e.g., amplitude) required to estimate the magnitude have been measured (see 'System Measures Signal Features' UC).

POSTCONDITIONS

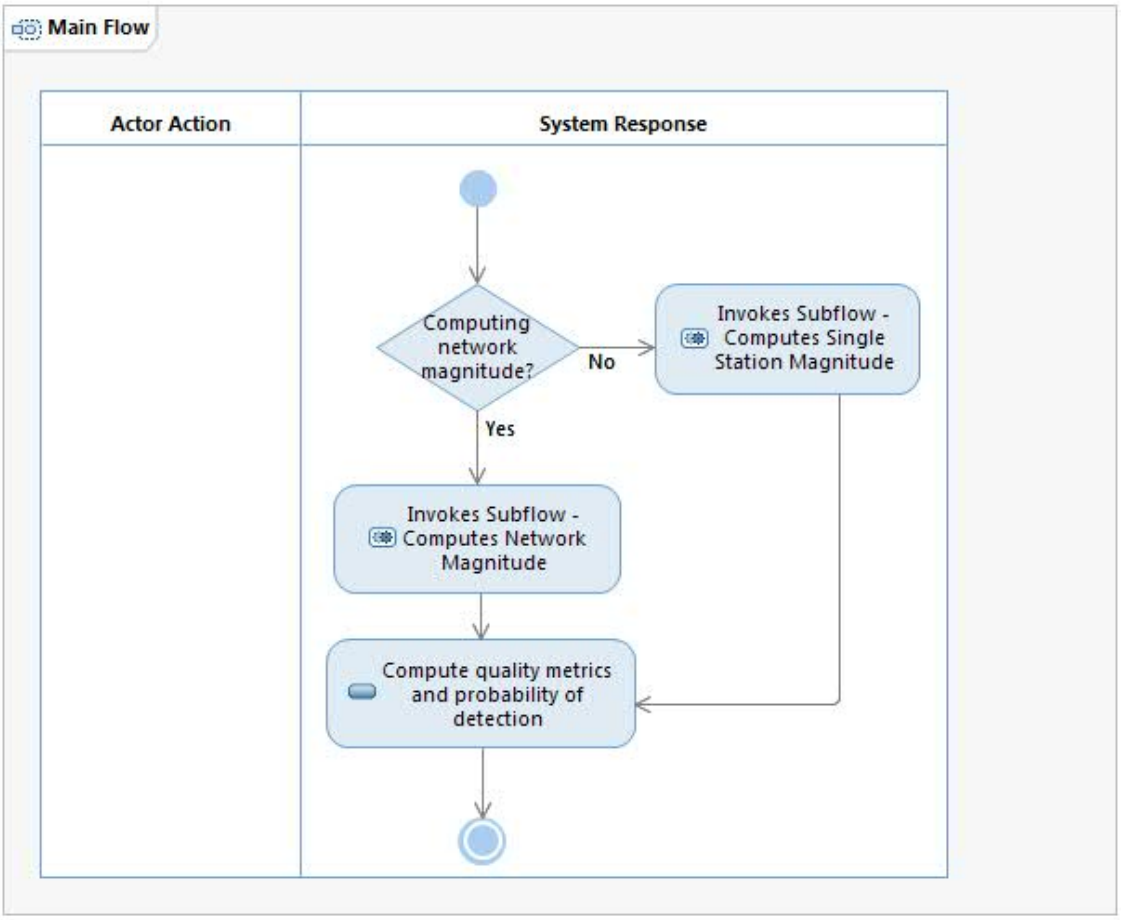
1. This use case updates an event hypothesis magnitude estimate.

ACTIVITY DIAGRAMS

Flow Overview



Main Flow



Action Descriptions

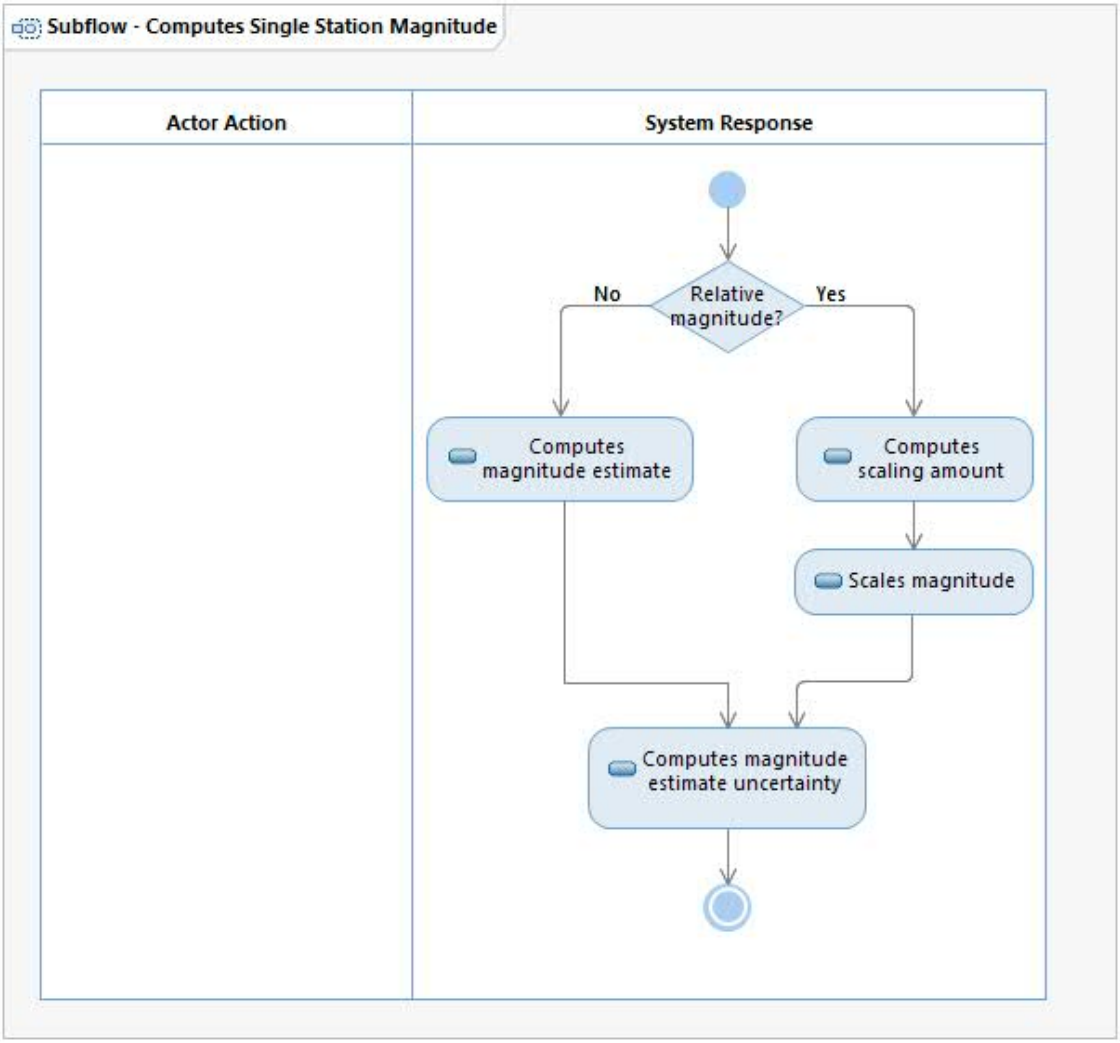
Action: "Compute quality metrics and probability of detection"

The System computes and updates the station quality metrics and station probability of detection for all stations related to this event. The System computes and updates the event quality metric for this event hypothesis. The System computes the quality metrics and probability of detection for each location solution of the event hypothesis.

Alternate Flows

None.

Subflow - Computes Single Station Magnitude



Action Descriptions

Action: "Computes magnitude estimate"

The System estimates a single station magnitude for an event hypothesis. The invoking use case specifies the magnitude estimate type such as one of ML, mb, or MS. The System uses only the magnitude defining signal detection feature measurements for the station's signal detections associated to the event hypothesis when estimating the single station magnitude. Signal detections of different phases are used for the different types of magnitude estimates. The System uses the event hypothesis' location, the station location, and a representation of the Earth's structure (e.g., an Earth model or an empirical model) to estimate the loss in a signal's amplitude between the source and its detection at the station due to attenuation and geometric spreading. When estimating Mwcoda, the System also uses waveform data from the station's channels to compute the required waveform envelopes and calculate moment rate spectra. For moment rate spectra calculations the invoking use case also provides the pre-signal detection noise window, defining behavior for each noise envelope, and whether the System should use theoretical or actual signal detections.

The System Maintainer configures default values for which signal detections are magnitude defining, the Earth or empirical models used to estimate loss in signal amplitude, and the signal enhancement (e.g., waveform filter) and waveform envelope parameters used by Mwcoda estimation (see 'Configures Processing Components' UC). The Analyst has the option to override these parameters (see 'Refines Event Magnitude' UC).

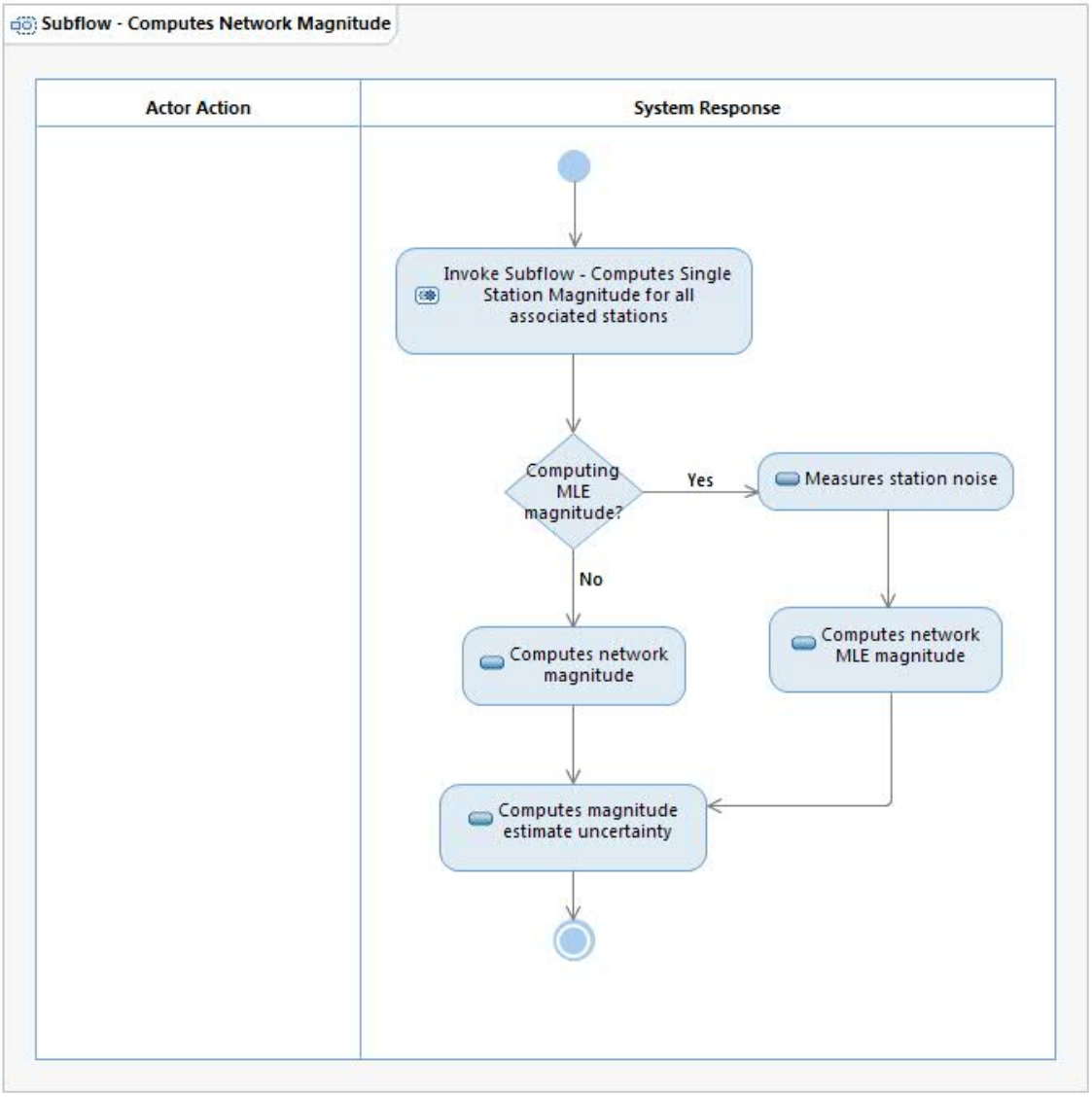
Action: "Computes scaling amount"
The System calculates the single station relative magnitude (e.g., mbrel) scaling factor for an event hypothesis. The invoking use case provides the selected event hypothesis and magnitude estimate to scale. The invoking use case also provides either a signal detection amplitude measurement or a waveform amplitude scaling factor (such as one computed using waveform correlation, see 'System Detects Events using Waveform Correlation' UC) to use when finding the magnitude scaling factor.

Action: "Scales magnitude"
The System estimates the event hypothesis magnitude by scaling the selected event hypothesis' magnitude.

Action: "Computes magnitude estimate uncertainty"
The System computes the magnitude estimate's uncertainty based on uncertainties of the signal detection feature measurements and estimated amplitude attenuation used to estimate the event magnitude. For relative magnitudes, the System uses the selected event hypothesis' magnitude uncertainty and the waveform cross correlation coefficient (if the event hypothesis was detected using waveform correlation) to compute the magnitude estimate's uncertainty.

Alternate Flows
1. Action "Computes scaling amount" – if the System is estimating mbrel for an event hypothesis detected using waveform correlation and the waveform cross correlation coefficient is less than a threshold preconfigured by the System Maintainer (see 'Configures Processing Components' UC), then mbrel is not estimated and this use case ends, and returns to the invoking use case.

Subflow - Computes Network Magnitude



Action Descriptions

Action: "Invoke Subflow - Computes Single Station Magnitude for all associated stations"

The System estimates the single station magnitudes required to estimate a network magnitude. The System estimates a single station magnitude for each station that has a signal detection of the phase required for the network magnitude estimate associated to the event hypothesis. The invoking use case specifies the type of network magnitude (e.g., ML, mb, or MS) the System estimates.

Action: "Measures station noise"

The System measures the station noise amplitude and uncertainty for each station that did not detect the event hypothesis. This measurement uses the station's noise recorded during the time interval it would have detected the phase required for the network magnitude estimate.

Action: "Computes network MLE magnitude"

The System computes a Maximum Likelihood Estimate (MLE) mb and MS magnitude (mbMLE and MSMLE) for the event hypothesis using the single station magnitude estimates (including uncertainties) for stations with signal detections associated to the event hypothesis and the station noise measurements (and uncertainties) for stations without signal detections associated to the event hypothesis.

Action: "Computes network magnitude"
The System estimates a network magnitude (e.g., ML, mb, or MS) for the event hypothesis as a function of the single station magnitude estimates from stations with relevant (i.e., of the correct phase) magnitude defining signal detections associated to the event hypothesis.

The System Maintainer configures any required network magnitude specific parameters (e.g., coefficients of functions used to estimate network magnitude from single station magnitude) (see 'Configures Processing Components' UC). The System Maintainer configures the default magnitude defining states (see 'Configures Processing Components' UC). The Analyst has the option to override these parameters (see 'Refines Event Magnitude' UC).

Action: "Computes magnitude estimate uncertainty"
The System calculates the network magnitude estimate's uncertainty based on the single station magnitude estimate uncertainties. For MLE magnitude estimates the System also uses uncertainty in measured noise at the non-detecting stations.

Alternate Flows
None.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1580: [*Threshold*] The System shall recompute the event hypothesis quality metric for an event hypothesis when any of the event hypothesis quality statistics used to calculate the event hypothesis quality metric are updated.

S-1588: [*Threshold*] The System shall store the event quality metric for each event hypothesis.

S-1650: [*Threshold*] The System shall compute single station magnitude estimates using the station's event hypothesis magnitude estimate calculation parameters.

S-1651: [*Threshold*] The System shall compute network magnitude estimates using single station magnitude estimates and the network magnitude estimate combining function's parameter values.

S-1652: [*Threshold*] The System shall compute uncertainties for all event hypothesis magnitude estimates.

S-1663: [*Threshold*] The System shall store uncertainties for all event hypothesis magnitude estimates.

S-1664: [*Threshold*] The System shall store each single station magnitude estimate for each event hypothesis.

S-1665: [*Threshold*] The System shall store each network magnitude estimate for each event hypothesis.

S-1666: [*Threshold*] The System shall store the defining/non-defining state for each station magnitude associated to a stored event hypothesis.

S-1828: [*Threshold*] The System shall compute amplitude correction factors using Q models where Q in the Earth varies as a function of phase, frequency and depth, but not latitude or longitude.

S-2036: [*Threshold*] The System shall use configured default defining/non-defining state settings and precedence rules to determine the initial defining/non-defining state for each parameter.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-6486: [*Threshold*] The System shall compute the mb body wave magnitude estimate.

S-6487: [*Threshold*] The System shall compute the mbMLE maximum likelihood body wave magnitude estimate.

S-6488: [*Threshold*] The System shall compute the mbrel relative body wave magnitude estimate.

S-6489: [*Threshold*] The System shall compute the ms surface wave magnitude estimate.

S-6490: [*Threshold*] The System shall compute the msVMAX surface wave magnitude estimate.

S-6491: [*Threshold*] The System shall compute the msMLE maximum likelihood surface wave magnitude estimate.

S-6492: [*Threshold*] The System shall compute the ml local magnitude estimate.

S-6493: [*Threshold*] The System shall compute the mwcoda coda magnitude estimate.

S-6494: [*Threshold*] The System shall compute infrasound magnitude.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Attenuation - The decrease in amplitude of a signal due to loss of energy as the signal propagates away from its source. Attenuation consists of two components: intrinsic attenuation, which is the phenomenon in which kinetic energy is converted to heat by anelastic processes or internal friction, and scattering attenuation, which is caused by energy reflecting off of small scale material heterogeneities. In addition to attenuation, geometric spreading also acts to modify the amplitude of seismic signals.

Defining/Non-Defining - Any observation that contributes to the determination of an event attribute is considered to be "defining" for that attribute. The detection of an event, the location of an event (see event location), the magnitude of an event (see event magnitude, network), and the source type assigned to an event are all determined by specific types of defining observations (travel time, azimuth, slowness, amplitude) from one or more phases recorded by one or more stations. If an observation is linked to an event (associated), but does not contribute to the calculation of an event attribute, then it is considered to be non-defining for that attribute.

Event Hypocenter - An event's 3D spatial location as described by latitude, longitude, and depth. This is in contrast to an event epicenter, which refers only to the latitude and longitude (i.e., the position on a map).

Event Hypothesis - A proposed solution for an Event. Each event consists of a sequence of event hypotheses that describe an evolution to a final best model of the event. Each event hypothesis is composed of a set of associated signal detections and has one or more event hypothesis location solutions, one of which must be designated as preferred.

Event Magnitude, Network - An estimate of the size of a seismic event determined by combining the set of available station event magnitudes (see event magnitude, station). Separate network event magnitudes can be calculated for each available station magnitude type (e.g., mb, Ms).

Event Magnitude, Station - An estimate of the size of a seismic event determined by processing the waveform data recorded by one station. Separate station event magnitudes can be calculated for different magnitude types (e.g., mb, Ms).

Geometric Spreading - The decrease in signal amplitude as a wavefront expands away from its source that accounts for the increasing wavefront size.

Magnitude Estimation - The process whereby the magnitude (size) of an event is estimated based on the observed waveform characteristics for a specified seismic phase at one or more stations. Magnitude is calculated for each station observing the event (see event magnitude, station) and these results are combined to come up with a network magnitude (see event magnitude, network). The magnitude calculation requires that the location of the event (see event

location) be known, so location must be estimated before magnitude. A magnitude estimation calculation formula must account for the decreases in signal amplitude between source and receiver due to geometric spreading and anelastic attenuation. These factors are determined empirically based on the observed amplitudes for a set of events of well-known sizes.

Magnitude Type - A particular magnitude estimation method based on a specified phase, frequency band, and instrument.

Maximum Likelihood Magnitude Estimation (MLE) - A method of estimating the magnitude of an event using information from both detecting and non-detecting stations. For the latter, an amplitude measurement is made at the theoretical arrival time of the phase used for the type of magnitude being calculated (see magnitude type); the assumption is that the amplitude for that phase from the event must be less than or equal to the amplitude measured at the theoretical arrival time.

Relative Event Magnitude Estimation - The process of estimating magnitudes (see magnitude estimation) for events in a localized source region, by scaling relative to a designated master event with a well-established magnitude.

Station Magnitude - See event magnitude, station.

IDC Specific:
None.

NOTES

General:
1. This use case describes the types of magnitude estimates made by the System. The types of single-station and network magnitudes that the System can compute include but are not limited to: ML, mb, MS, mbMLE, MSMLE, MSVMAX, Mwcoda, mbrel and infrasound magnitudes. New or different types of magnitude estimates are possible as are new types of amplitude measurements (see ‘System Measures Signal Features’ UC).

2. It is expected that this UC will be invoked multiple times for different magnitude types. All magnitude estimates will be stored.

3. Although this Use Case does not store data, this Use Case maps to storage specifications because it creates data that are stored in other Use Cases. See 'System Detects Event' UC and ‘Refines Event’ UC.

4. The System sets default defining states based on rules previously configured by the System Maintainer (see 'Configures Processing Components' UC).

IDC Specific:
None.

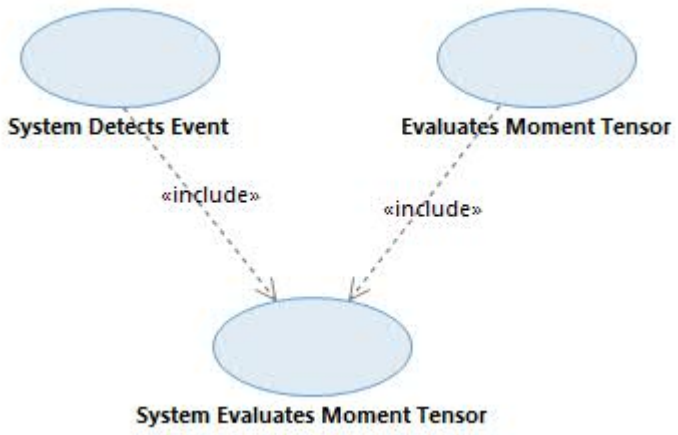
OPEN ISSUES

None.

IDC Use Case Report

UC-02.10 System Evaluates Moment Tensor

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the System evaluates the moment tensor for an event. The System inverts observed ground motion data from the event to determine the moment tensor. The System decomposes the moment tensor into deviatoric and isotropic components. The System decomposes the deviatoric component into best-fitting double couple and compensated linear vector dipole (CLVD) components.

ACTOR DESCRIPTIONS

None.

PRECONDITIONS

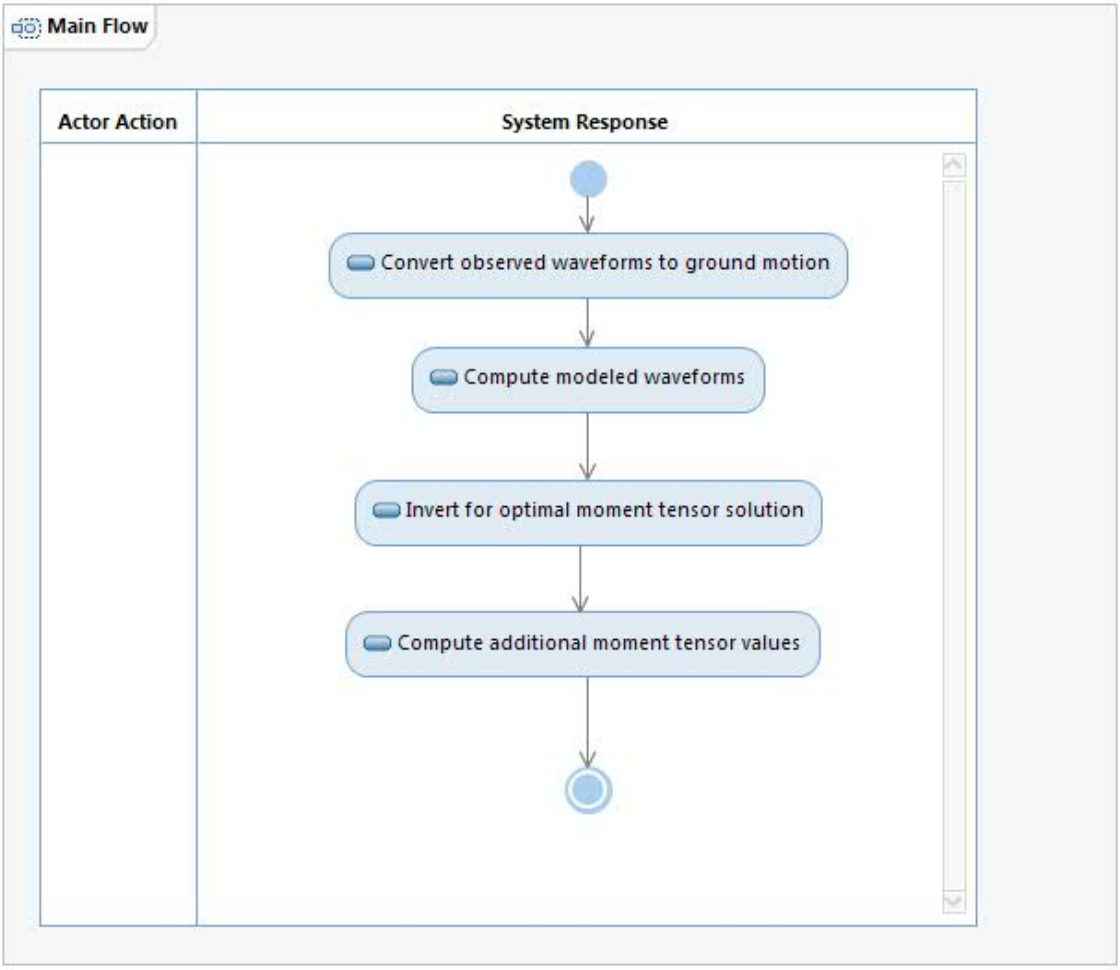
1. An event hypothesis is available for moment tensor estimation.

POSTCONDITIONS

1. This use case updates an event hypothesis moment tensor estimate.

ACTIVITY DIAGRAMS

Main Flow



Action Descriptions

Initial Action

Moment tensor processing uses these parameters:
a. Synthetic waveform frequency band and filtering parameters
b. Station defining settings
c. Moment tensor algorithm parameters (station distance limits, time and depth discretization, confidence level)
d. Earth model for waveform modeling (potentially different for each station)

Default values for moment tensor processing parameters are set by the System Maintainer (see 'Configures Processing Components' UC). The Analyst has the option to override these parameters (see 'Evaluates Moment Tensor' UC).

Action: "Convert observed waveforms to ground motion"

The System converts observed waveforms to ground displacement and determines station defining flags using these steps:
1. deconvolve the instrument response for each waveform

2. filter to match the synthetic waveform frequency band
3. compute waveform SNR based on signal amplitude in signal and noise windows
4. set moment tensor station defining flags based on Waveform QC Masks, SNR, and distance limits

Action: "Compute modeled waveforms"
The System computes modeled (synthetic) waveforms (Green functions) for each defining station, using the event and station locations, Earth model, frequency band and filtering parameters, and moment tensor parameters.

Action: "Invert for optimal moment tensor solution"
The System finds the optimal combination of event force couples (the moment tensor solution) to maximize variance reduction between the set of modeled (synthetic) and observed waveforms (for the full moment tensor solution), and potentially to maximize the percent of double couple in the solution (for the deviatoric moment tensor solution). The System computes both a full moment tensor solution and a deviatoric moment tensor solution. The System further decomposes the deviatoric component into best-fitting double couple (DC) and compensated linear vector dipole (CLVD) components.

The System calculates the optimal moment tensor solution for a sampling of event time and depth values near the event location values. The System performs multiple inversions of each solution using station bootstrapping to calculate uncertainty bounds for a given confidence level.

Action: "Compute additional moment tensor values"
The System calculates a goodness of fit metric between the modeled and observed waveforms for each station. The System calculates the scalar seismic moment, percentage of double couple and isotropic components, compressional and shear phase radiation patterns, double couple fault planes, and the parameters used for a source type plot (e.g., Hudson diagram).

Alternate Flows
None.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1684: [*Objective / Priority 1*] The System shall calculate Green functions using region specific 1D Earth models.

S-1685: [*Objective / Priority 1*] The System shall calculate synthetic displacement waveforms.

S-1686: [*Objective / Priority 1*] The System shall calculate synthetic velocity waveforms.

S-1687: [*Objective / Priority 1*] The System shall calculate synthetic seismograms using Green functions computed using frequency-wavenumber integration.

S-1688: [*Objective / Priority 1*] The System shall compute Green functions in real time while computing moment tensor solutions.

S-1689: [*Objective / Priority 1*] The System shall apply the same filter to observed and synthetic waveforms during moment tensor calculations.

S-1690: [*Objective / Priority 1*] The System shall compute moment tensor solutions using waveform data from one or more seismic stations.

S-1691: [*Objective / Priority 1*] The System shall decompose moment tensor solutions into isotropic and deviatoric components.

S-1692: [*Objective / Priority 1*] The System shall decompose deviatoric moment tensor solutions into double couple and compensated linear vector dipole (CLVD) components.

S-1693: [*Objective / Priority 1*] The System shall compute the percentage of deviatoric moment tensor solutions belonging to the double couple components.

S-1694: [*Objective / Priority 1*] The System shall compute shear phase radiation patterns for moment tensor solutions.

S-1695: [*Objective / Priority 1*] The System shall compute compressional phase radiation patterns for moment tensor solutions.

S-1696: [*Objective / Priority 1*] The System shall compute double couple fault planes from moment tensor solutions.

S-1697: [*Objective / Priority 1*] The System shall compute the scalar seismic moment from moment tensor solutions.

S-1698: [*Objective / Priority 1*] The System shall calculate station specific goodness of fit between theoretical and observed waveforms for moment tensor solutions.

S-1711: [*Objective / Priority 1*] The System shall store the type of ground motion used by moment tensor calculations.

S-1712: [*Objective / Priority 1*] The System shall store the filter applied to observed and synthetic waveforms when computing moment tensor solutions.

S-1713: [*Objective / Priority 1*] The System shall store the Green functions used to compute a moment tensor solution.

S-1714: [*Objective / Priority 1*] The System shall store the Earth models used to compute a moment tensor solution.

S-1715: [*Objective / Priority 1*] The System shall store the elements of moment tensor solutions.

S-1716: [*Objective / Priority 1*] The System shall store the percentage of deviatoric moment tensor solutions belonging to the double couple components.

S-1717: [*Objective / Priority 1*] The System shall store the double couple fault plane solution computed from a moment tensor solution.

S-1718: [*Objective / Priority 1*] The System shall store the scalar seismic moment computed from a moment tensor solution.

S-1719: [*Objective / Priority 1*] The System shall store the station specific goodness of fit between theoretical and observed waveforms for moment tensor solutions.

S-1722: [*Objective / Priority 1*] The System shall compute Hudson's ε value for moment tensor solutions.

S-1723: [*Objective / Priority 1*] The System shall compute Hudson's k value for moment tensor solutions.

S-1724: [*Objective / Priority 1*] The System shall use bootstrap resampling on the stations used in moment tensor solutions to estimate the distributions of ε for the moment tensor solutions.

S-1725: [*Objective / Priority 1*] The System shall use bootstrap resampling on the stations used in moment tensor solutions to estimate the distributions of k for the moment tensor solutions.

S-1726: [*Objective / Priority 1*] The System shall use the distributions of ε and k from bootstrap resampling on moment tensor solutions to compute the uncertainty bound on ε and k at a fixed confidence level for the moment tensor solutions.

S-1735: [*Objective / Priority 1*] The System shall store the ε value computed for moment tensor solutions.

S-1736: [*Objective / Priority 1*] The System shall store the k value computed for moment tensor solutions.

S-1737: [*Objective / Priority 1*] The System shall store the uncertainty bounds on ε and k computed for moment tensor solutions.

S-1738: [*Objective / Priority 1*] The System shall store the confidence level of uncertainty bounds on ε and k computed for moment tensor solutions.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Compensated Linear Vector Dipole - The sub-portion of the deviatoric component of the moment tensor remaining after subtraction of the double couple component.

Deviatoric Component (of Moment Tensor) - The portion of the moment tensor remaining after subtraction of the isotropic component. The moment tensor for an idealized earthquake has only a deviatoric component.

Double Couple Component (of Moment Tensor) - The sub-portion of the deviatoric component of the moment tensor that represents two paired but opposing force couples.

Green Function - The modeled ground motion at one location produced by a unit force at another location. For moment tensor inversion, it is necessary to calculate Green functions corresponding to each of the fundamental force couples in the moment tensor for each seismic station.

Isotropic Component (of Moment Tensor) - The portion of the moment tensor that represents a purely explosive/implosive source. The moment tensor for an idealized explosion has only an isotropic component.

Moment - The amount of energy released by a seismic event. Moment is the scalar size of the moment tensor.

Moment Tensor - A 3 x 3 matrix of the 9 fundamental force couples that describe the focal mechanism for a particular event. A moment tensor can be decomposed into various components to provide insight into the focal mechanism. The most basic decomposition is into isotropic and deviatoric components.

Moment Tensor Inversion - The process of determining the values of the force couples in the moment tensor. Moment tensor inversion is based on fitting the observed waveforms at a set of seismic stations with modeled waveforms based on a sum of the properly scaled Green functions. The scaling factors are the elements of the moment tensor.

IDC Specific:
None.

NOTES

General:

1. Although this Use Case does not store data, this Use Case maps to storage specifications because it creates data that are stored in other Use Cases. See 'System Detects Event' UC and ‘Refines Event’ UC.

IDC Specific:
None.

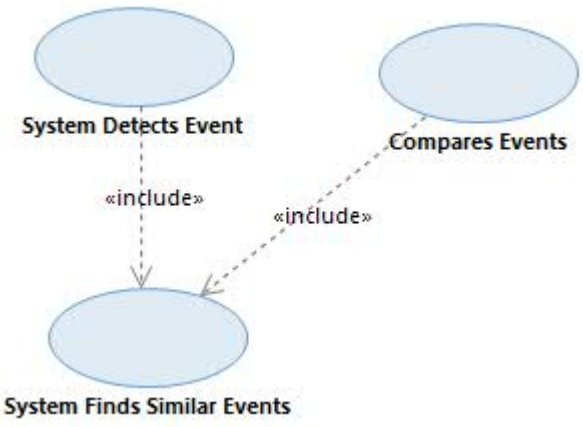
OPEN ISSUES

None.

IDC Use Case Report

UC-02.11 System Finds Similar Events

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the System finds events that are similar to a specified event. The System uses event parameters (e.g., latitude and longitude), patterns of associated signal detections, or waveform correlation as similarity metrics. The System uses default similarity parameters configured by the System Maintainer (see 'Configures Processing Components' UC) or override parameters set by the Analyst (see 'Compares Events' UC).

ACTOR DESCRIPTIONS

None.

PRECONDITIONS

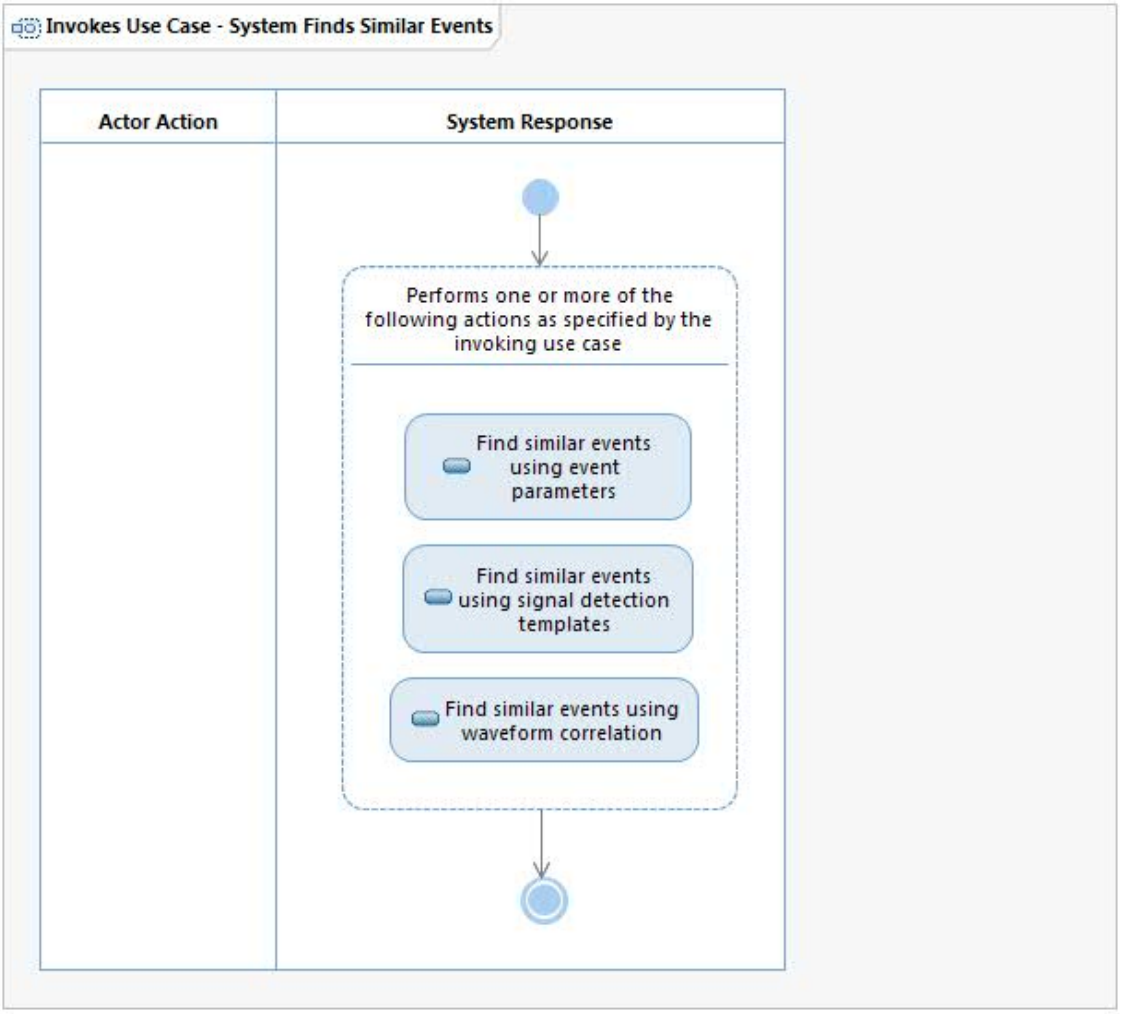
None.

POSTCONDITIONS

None.

ACTIVITY DIAGRAMS

Main Flow



Action Descriptions

Action: "Find similar events using event parameters"

Find events that match parameters configured by the System Maintainer or selected by the Analyst.

Parameters can include:

- latitude/longitude range
- magnitude range
- date/time range
- source type
- processing stage

Action: "Find similar events using signal detection templates"

Find events that match signal detection templates configured by the System Maintainer or selected by the Analyst.

Templates are defined by:

- stations used in template
- phases used in template
- reference event location

Action: "Find similar events using waveform correlation"
Find events that correlate to the waveform using parameters configured by the System Maintainer or selected by Analyst.
Parameters can include:
- station used for waveform correlation
- waveform processing options (filtering, windowing)
- correlation options (thresholds)

Alternate Flows
None.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1401: [*Threshold*] The System shall detect signals of interest in waveform data by correlating the waveform with waveforms from historic event hypotheses.

S-1504: [*Threshold*] The System shall use the seismic, hydroacoustic, and infrasound network signal association parameters to form event hypotheses from any combination of seismic, hydroacoustic, and infrasound signal detections meeting the signal association event hypothesis formation criteria.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-2344: [*Threshold*] The System shall use waveform correlation to find historical event hypotheses occurring within a specified distance from an event hypothesis being analyzed.

S-3026: [*Threshold*] The System shall build new events using signal detection templates.

S-5596: [*Threshold*] The System shall use station-to-event distance when associating signal detections to events.

S-5597: [*Threshold*] The System shall use event magnitude when associating signal detections to events.

S-5968: [*Threshold*] The System shall associate signal detections to existing events using signal detection templates.

S-6241: [*Threshold*] The System shall find similar events using signal detection templates.

S-6242: [*Threshold*] The System shall find similar events by matching event parameters.

S-6243: [*Threshold*] The System shall find similar events using waveform correlation.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Event Catalog - A named collection of events.

Event Hypothesis - A proposed solution for an Event. Each event consists of a sequence of event hypotheses that describe an evolution to a final best model of the event. Each event hypothesis is composed of a set of associated signal detections and has one or more event hypothesis location solutions, one of which must be designated as preferred.

Reference Event - An event recognized by an analyst as containing unique or important characteristics that may help in the analysis of future events that are related. For example, a nuclear test could be designated as a reference event for any subsequently detected nearby events thought to be tests.

Signal Detection - A specific interval on a waveform marking the arrival of a signal of interest. Other portions of the waveform are noise.

Signal Detection Template - The set of signal detections associated with an event. The relative timing of the signal detections is indicative of the location of the event. Shifting the timing of a signal detection template, and matching it with signal detections on current waveforms, can help determine whether a similar event has occurred, and aid in identifying and associating signal detections to existing events. These templates can be particularly helpful for building events in an aftershock or swarm sequence.

Waveform Correlation Event Processing - A technique used to find events by matching current waveforms to waveforms of known historical events. Waveform similarity is determined using the correlation coefficient. When a match is found, there is high probability that a new event has occurred, which is of the same source type and near the same location (see event location) as the historical event.

IDC Specific:
None.

NOTES

General:
1. The geographic parameters can come from the map.

IDC Specific:
None.

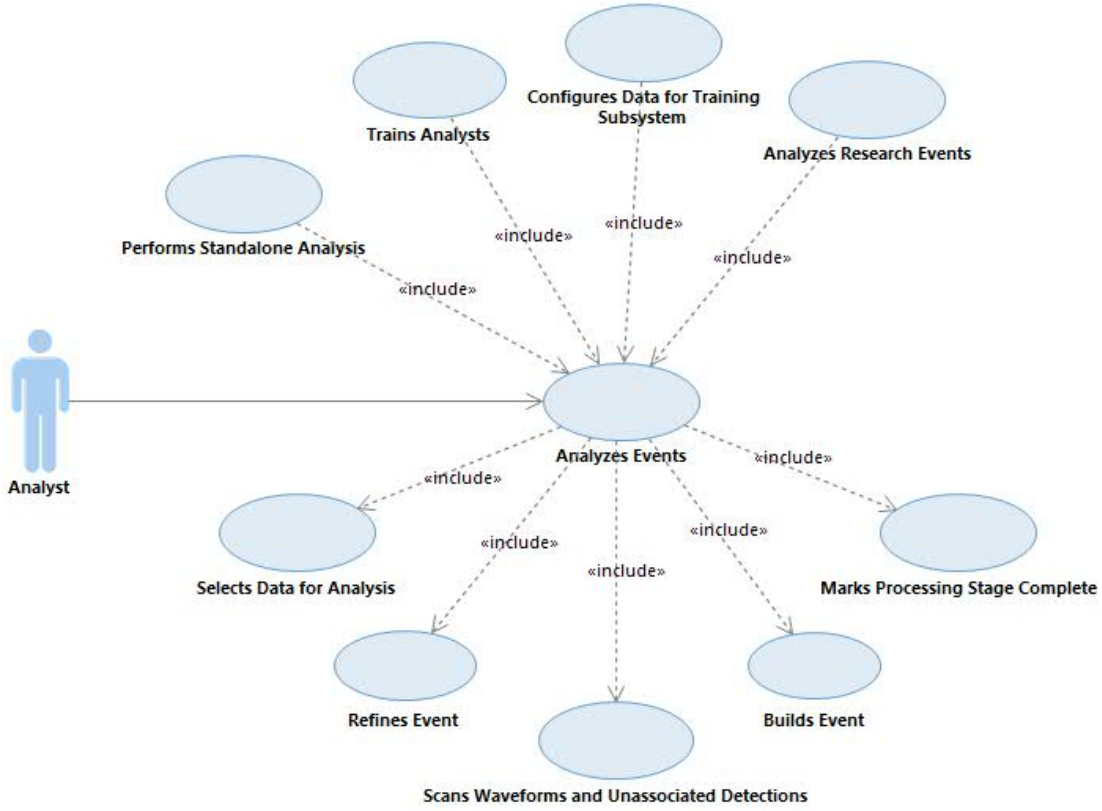
OPEN ISSUES

None.

IDC Use Case Report

UC-03 Analyzes Events

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the Analyst analyzes event hypotheses created by either pipeline processing or a previous Analyst and builds new events. The Analyst selects data to analyze (see 'Selects Data for Analysis' UC), refines event hypotheses for selected events (see 'Refines Event' UC), reviews waveforms and unassociated detections (see 'Scans Waveforms and Unassociated Detections' UC), and builds new event hypotheses for events missed by the System or previous Analysts (see 'Builds Event' UC). When finished with the analysis, the Analyst marks the processing stage as complete for the selected data (see 'Marks Processing Stage Complete' UC) to prepare the event hypotheses for further analysis in subsequent processing stages.

ACTOR DESCRIPTIONS

Analyst - The Analyst is a System User who analyzes events. This actor includes all the traditional analysis roles. Any Analyst can access all System event analysis capabilities from a use case perspective. Individual analyst capabilities may be further specified by operations procedures.

PRECONDITIONS

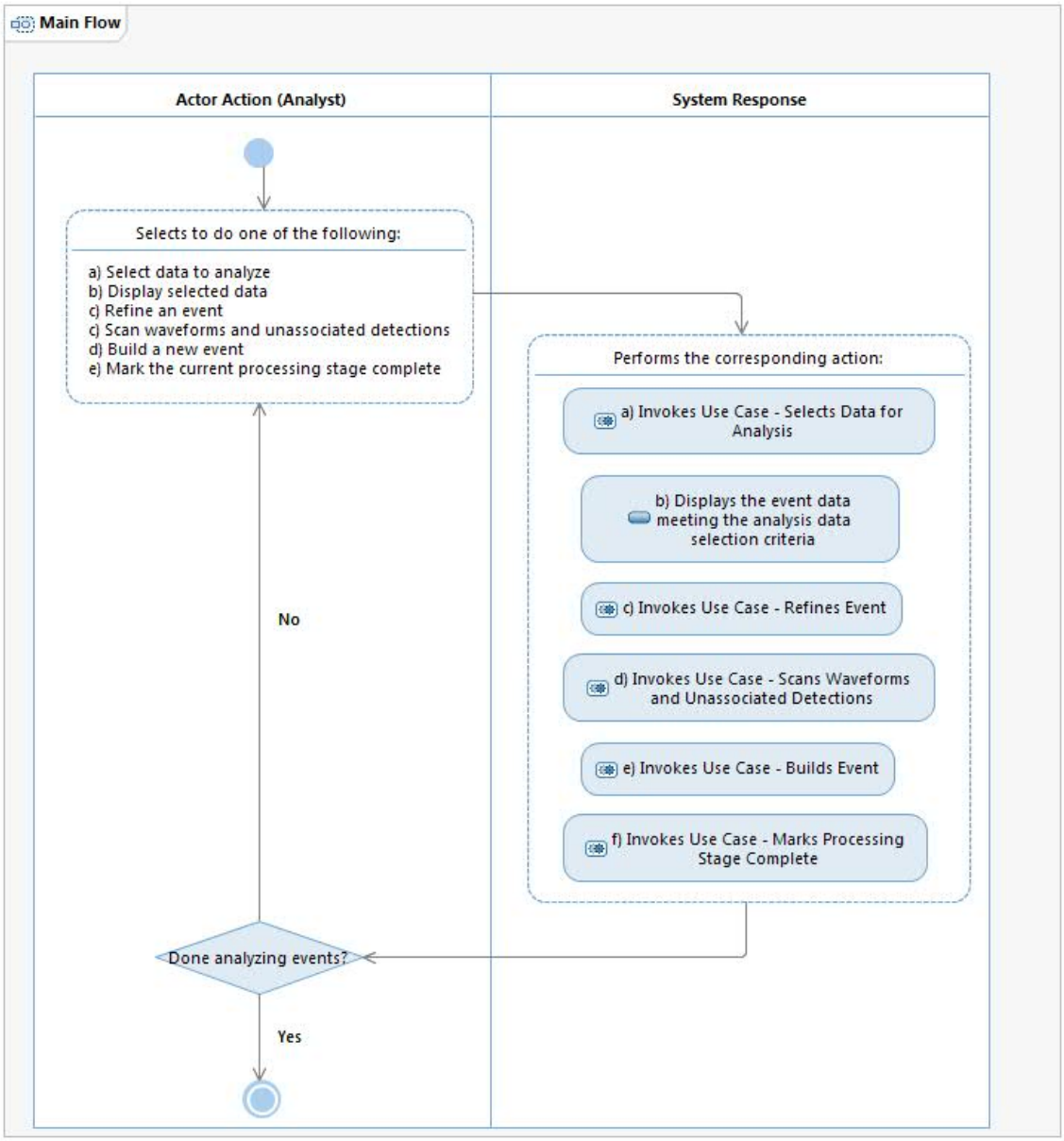
None.

POSTCONDITIONS

None.

ACTIVITY DIAGRAMS

Main Flow



Action Descriptions

Action: "b) Displays the event data meeting the analysis data selection criteria"

Displays the waveforms, signal detections, and event data for the selected Analysis Time Interval, event set, or list of events added to an event catalog.

Alternate Flows

1. Any Actor Action - The Analyst may select to cancel, in which case, the use case ends.

2. Action "Selects to do one of the following:" - The Analyst must perform the "a) Select data to analyze" and "b) Displays the event data meeting the analysis data selection criteria" steps prior to the other steps, but the other steps may be skipped, repeated or performed in any order.

3. Action "Displays the event data meeting the analysis data selection criteria" - If the user allocates event data for working and the event data are already allocated for working by another user, this Analyst is notified.

4. Any Action - If late data arrives that is relevant to the analysis session, the Analyst is notified.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1158: [*Objective / Priority 2*] The System shall notify the Analyst within 1 minute of acquisition when new waveform data arrives during a waveform analysis session that is relevant to that session.

S-1159: [*Objective / Priority 2*] The System shall notify the Analyst within 1 minute of acquisition when new alphanumeric data becomes available during a waveform analysis session that is relevant to that session.

S-1872: [*Threshold*] The System shall provide the Analyst the capability to interrupt automated event hypothesis processing to analyze data if configured.

S-1879: [*Threshold*] The System shall provide the Analyst the capability to analyze any data stored on the System where station configuration data exists.

S-1919: [*Threshold*] The System shall provide the Analyst the capability to analyze events in any order.

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2176: [*Threshold*] The System shall provide a team of 10 concurrent analysts the capability to process up to 2000 seismic event hypotheses per 24 hour day.

S-5957: [*Threshold*] The System shall provide the Analyst the capability to view the preferred event hypothesis for each event.

S-6485: [*Objective / Priority 2*] The System shall notify the Analyst within 1 minute of data creation when new alphanumeric data (e.g. events, signal detections) is created during a waveform analysis session that is relevant to that session.

IDC Specific:

S-5669: [*IDC only, Objective / Priority 1*] The System shall provide the Analyst the capability to remotely view waveform processing results from any location.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Analysis Time Interval - The time interval bounding the data reviewed by an analyst. Those data include waveforms, event hypotheses and their associated signal detections, and unassociated signal detections.

Event Hypothesis - A proposed solution for an Event. Each event consists of a sequence of event hypotheses that describe an evolution to a final best model of the event. Each event hypothesis is composed of a set of associated signal detections and has one or more event hypothesis location solutions, one of which must be designated as preferred.

Interactive Processing - Analyst directed data processing. Interactive processing can be performed to review and refine existing event hypotheses (automatic or analyst-built) or to build new event hypotheses missed by prior processing.

Operational Processing Time Period - The time during which analysts may refine and save events without special procedures (currently 45 days).

Processing Stage - A named group of data processing and analysis functions, used to track status of increments of work performed on time intervals and events through the System. The flow of data through the System, from data acquisition, through automated processing and multiple reviews, to reporting of an event, is defined as a series of processing stages (e.g., Pipeline, traditional analysis roles). A processing stage may define automatic sequences (see processing sequences), interactive-only activities, or interactive and automatic sequences. A stage description includes a list of functions that are performed, entry criteria (time, event, or data availability triggers), and exit criteria (completion of processing, recognition of an important event, or declaration by an Analyst).

IDC Specific:
None.

NOTES

General:
1. If late data arrives that is relevant to the analysis session the Analyst is notified

IDC Specific:
None.

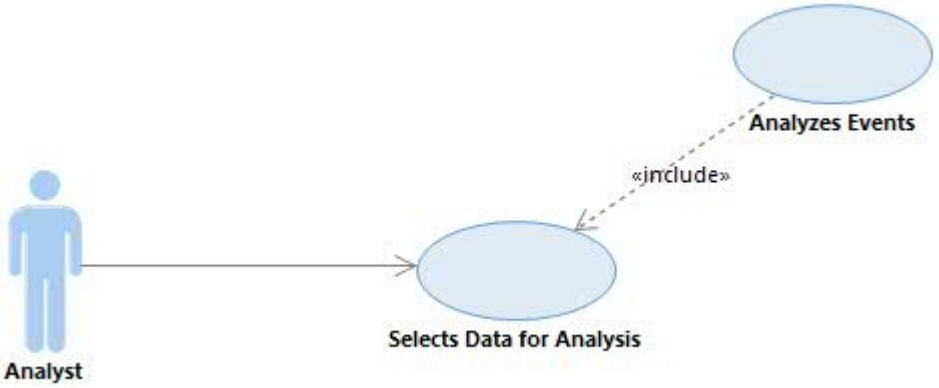
OPEN ISSUES

None.

IDC Use Case Report

UC-03.01 Selects Data for Analysis

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the Analyst selects data for analysis consistent with the selected processing stage. The Analyst creates an Analysis Time Interval based on an actual time interval or an Event Set. The Analyst selects the Analysis Time Interval to facilitate the analyzing of waveform data, unassociated detections, and System-built and Analyst-reviewed events within an Analyst specified time frame. The System updates relevant displays to indicate the selected data are being analyzed.

ACTOR DESCRIPTIONS

Analyst - The Analyst is a System User who analyzes events. This actor includes all the traditional analysis roles. Any Analyst can access all System event analysis capabilities from a use case perspective. Individual analyst capabilities may be further specified by operations procedures.

PRECONDITIONS

None.

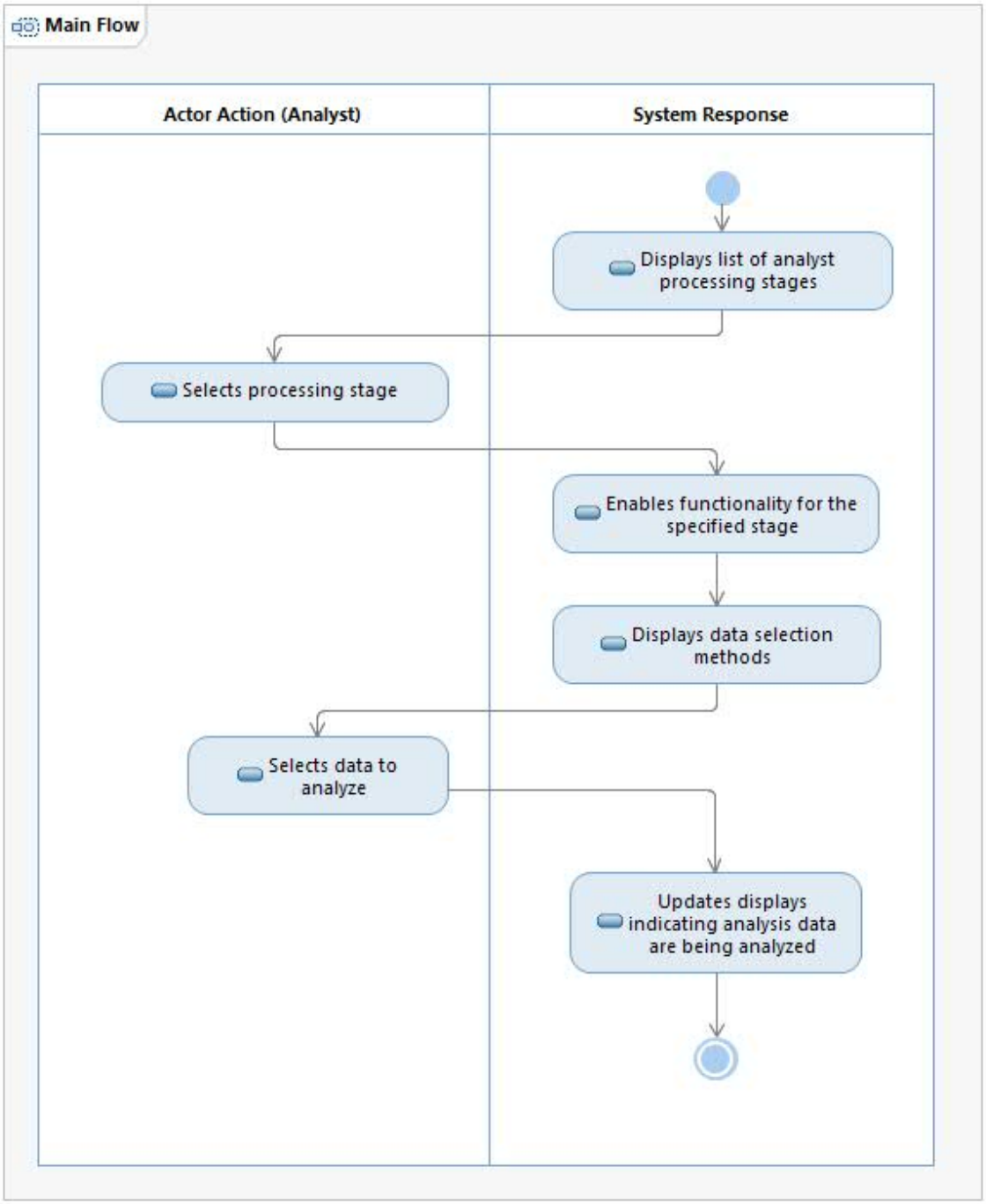
POSTCONDITIONS

1. An Analysis Time Interval, event set or list of events have been selected.

2. The selected waveforms, signal detections, and/or events are allocated for working by the Analyst.

ACTIVITY DIAGRAMS

Main Flow



Action Descriptions

Action: "Displays list of analyst processing stages"

The System displays a list of analyst processing stages that may be performed. This list is configured by the System Maintainer (see 'Defines Processing Sequence' UC).

Action: "Selects processing stage"

The Analyst selects a processing stage from the list.

Action: "Enables functionality for the specified stage"
The System tailors the session as appropriate for the selected Analyst processing stage (e.g., tailors the checklist of completion criteria).

Action: "Displays data selection methods"
The System displays the following analysis methods for the current processing stage:
- Time Interval method: This method provides the Analyst with an Analysis Time Interval to refine events, and scan waveforms and unassociated detections (see 'Refines Event' UC and 'Scans Waveforms and Unassociated Detections' UC).
- Event Set method: This method provides the Analyst with the ability to select a set of events for analysis based on a search of time interval, geographic region, magnitude and/or events added to an event catalog (see 'Refines Event' UC). This method is geared more for Researchers.

Action: "Updates displays indicating analysis data are being analyzed"
The System indicates that the selected waveforms and/or event are being analyzed (they are allocated for working).

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case, this use case ends.

2. Action “Selects data to analyze” – The user can select multiple time intervals and open all of those time intervals for processing.

3. Action “Selects data to analyze” – The user can select a time interval and choose to split the time interval into multiple time intervals.

4. Action “Selects data to analyze” – The user can add or view comments for the time interval selected.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1859: [*Threshold*] The System shall set the processing stage workflow status of a processing time interval to reflect analysis activity.

S-1874: [*Threshold*] The System shall provide the System User the capability to view the processing stage workflow status of processing time intervals.

S-1875: [*Threshold*] The System shall provide the Analyst the capability to allocate analysis time intervals for a processing stage.

S-1887: [*Threshold*] The System shall provide the Analyst the capability to select for analysis a time block of continuous waveform data.

S-1916: [*Threshold*] The System shall provide the Analyst the capability to select and retrieve an event and associated waveform data from an event catalog.

S-1918: [*Threshold*] The System shall provide the Analyst the capability to view a list of events from an event catalog.

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2342: [*Threshold*] The System shall mark as requiring Analyst review any event previously reviewed by an Analyst that has its signal detection associations subsequently modified by the System.

S-2588: [*Threshold*] The System shall set the processing stage workflow status of events to reflect analysis activity.

S-2589: [*Threshold*] The System shall provide the Analyst the capability to set the processing stage workflow status of a processing time interval.

S-2590: [*Threshold*] The System shall provide the Analyst the capability to set the processing stage workflow status of an event.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Analysis Time Interval - The time interval bounding the data reviewed by an analyst. Those data include waveforms, event hypotheses and their associated signal detections, and unassociated signal detections.

Event - The estimate by the System or Analyst of the occurrence of some transient source of energy within the Earth's body, oceans, or atmosphere that can be detected by seismic, hydroacoustic, and/or infrasonic sensors. For the same event, many different event hypotheses may be created at different processing stages. One of these event hypotheses must be designated as preferred.

Event Hypothesis - A proposed solution for an Event. Each event consists of a sequence of event hypotheses that describe an evolution to a final best model of the event. Each event hypothesis is composed of a set of associated signal detections and has one or more event hypothesis location solutions, one of which must be designated as preferred.

Event Set - The set of one or more event hypotheses that an analyst selects for analysis.

Geographic Region - An area on the surface of the Earth defined by either a polygon in geographic coordinates or an ellipse. Geographic Regions are used to visualize information on a map, for geospatial analysis, and in configuration of processing operations. Examples of geographic regions are Flinn-Engdahl seismic and geographical regions, but may be any arbitrary closed polygon or ellipse useful in the system. An “active geographic region” is a region definition that is valid in the system at a particular time. Regions may be created, changed, or made inactive.

Processing Stage - A named group of data processing and analysis functions, used to track status of increments of work performed on time intervals and events through the System. The flow of data through the System, from data acquisition, through automated processing and multiple reviews, to reporting of an event, is defined as a series of processing stages (e.g., Pipeline, traditional analysis roles). A processing stage may define automatic sequences (see processing sequences), interactive-only activities, or interactive and automatic sequences. A stage description includes a list of functions that are performed, entry criteria (time, event, or data availability triggers), and exit criteria (completion of processing, recognition of an important event, or declaration by an Analyst).

IDC Specific:
None.

NOTES

General:
1. The System marks for further review any Analyst-reviewed event that has been modified. These events can be accessed through 'Selects Data for Analysis' UC and 'Approves Events for Release' UC.

IDC Specific:
None.

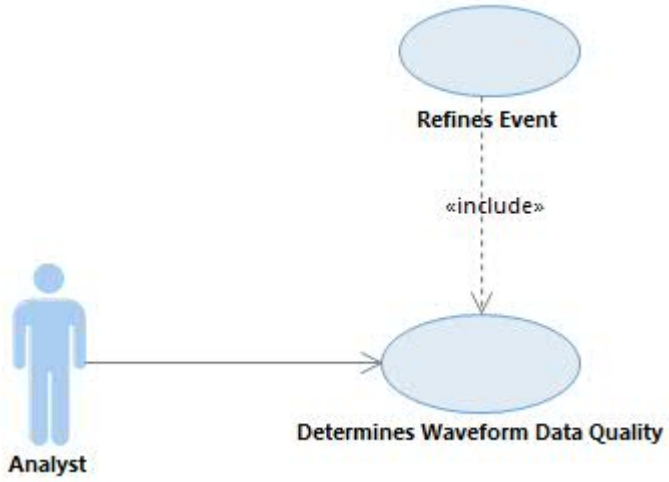
OPEN ISSUES

None.

IDC Use Case Report

UC-03.02.01 Determines Waveform Data Quality

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the Analyst determines the quality of the waveform data being analyzed. The Analyst reviews waveform data to determine data quality. The Analyst masks waveform data of insufficient quality that should not be used during event processing. The Analyst modifies or rejects masks created by the System (see 'System Determines Waveform Data Quality' UC).

ACTOR DESCRIPTIONS

Analyst - The Analyst is a System User who analyzes events. This actor includes all the traditional analysis roles. Any Analyst can access all System event analysis capabilities from a use case perspective. Individual analyst capabilities may be further specified by operations procedures.

PRECONDITIONS

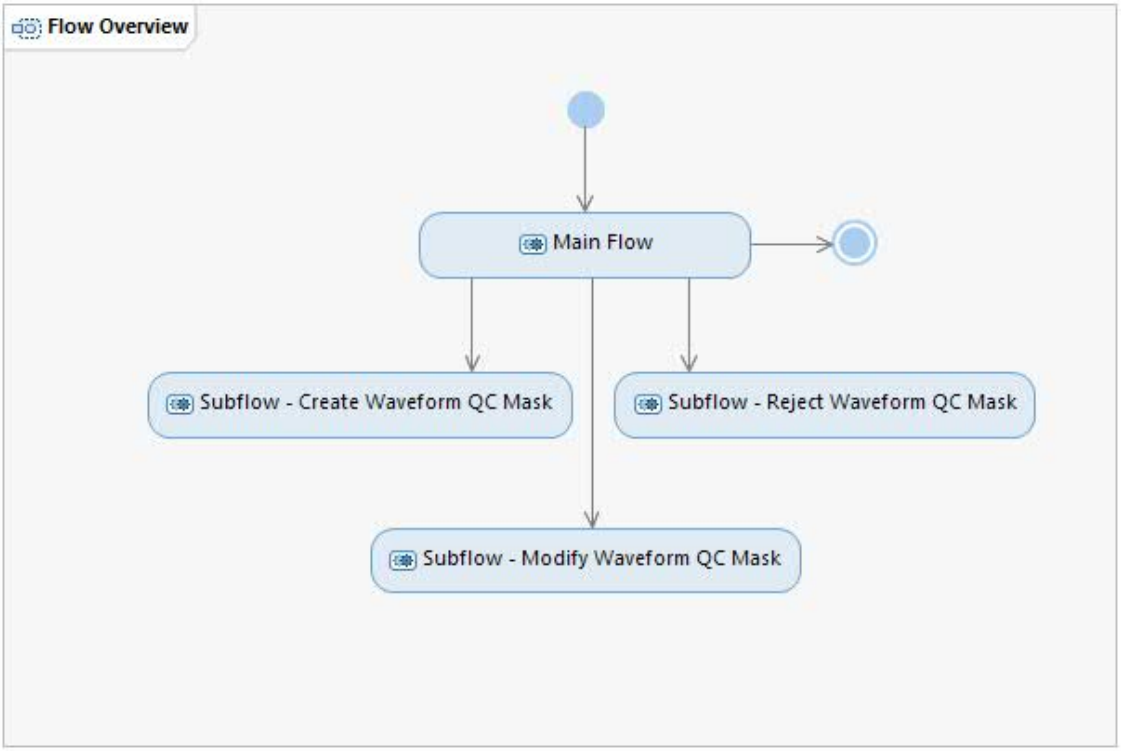
1. Analyst is viewing waveform data for an event hypothesis in the analysis session.

POSTCONDITIONS

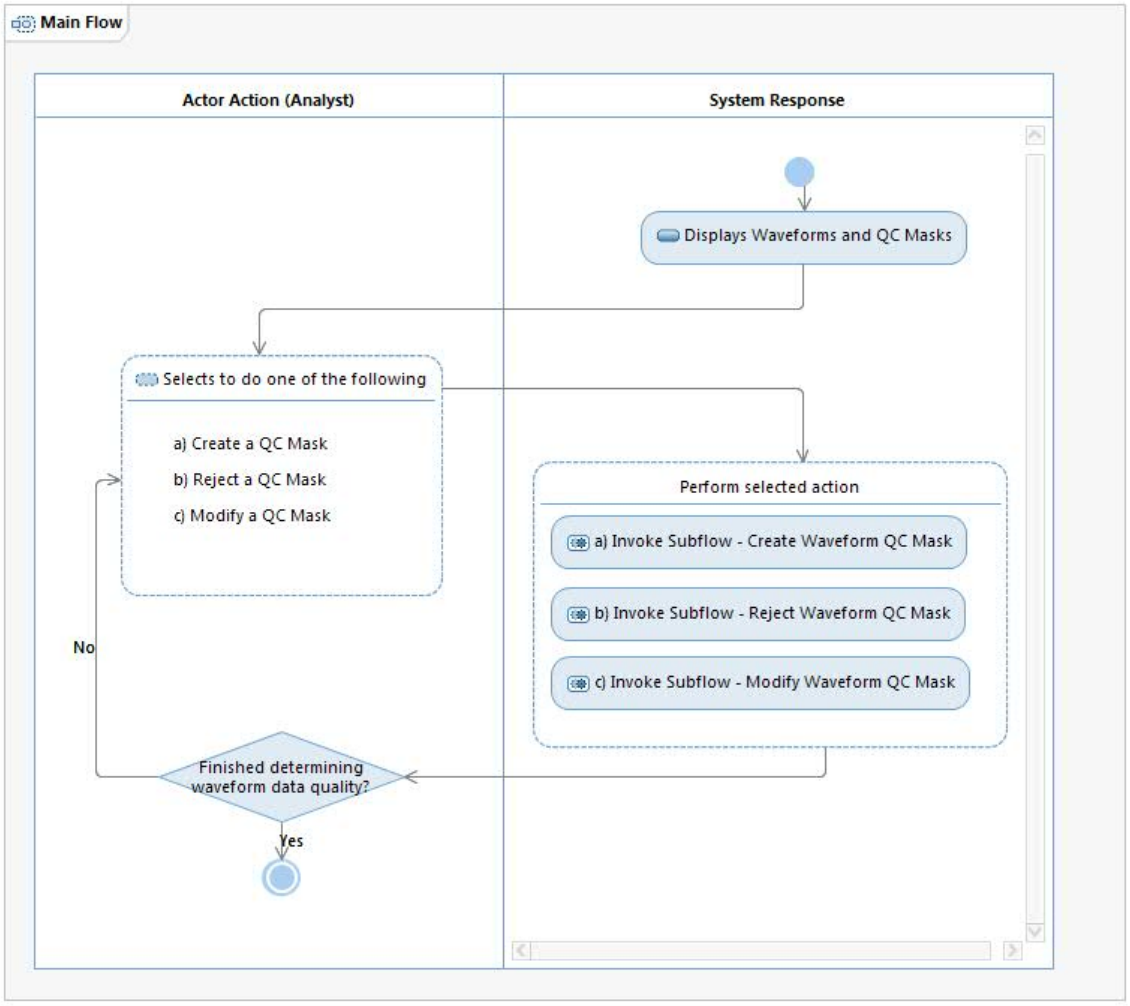
1. Masks are created for waveform sections containing data quality errors. Corrected copies of the data with QC issues are also created if configured.

ACTIVITY DIAGRAMS

Flow Overview



Main Flow



Action Descriptions

Action: "Displays Waveforms and QC Masks"

The System displays the selected portion of the waveform and any current masks applied to the waveform.

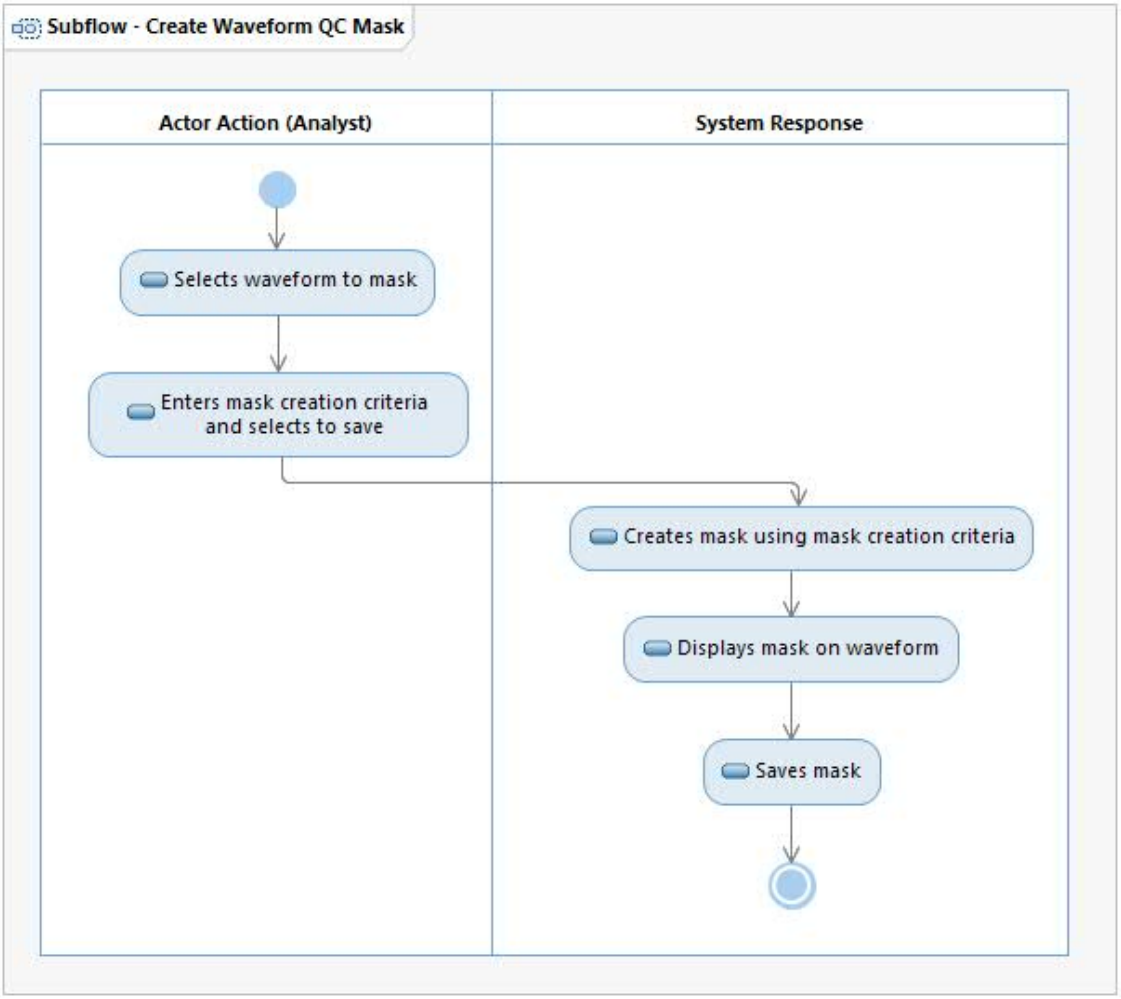
Decision: "Finished determining waveform data quality?"

The Analyst can repeat this process until they are satisfied with the quality of the data to be used for future processing.

Alternate Flows

1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to the 'Refines Event' UC.

Subflow - Create Waveform QC Mask



Action Descriptions

Action: "Enters mask creation criteria and selects to save"

The Analyst enters information about the mask which could include:
- Mask start time
- Mask end time
- Mask type
- Mask rationale

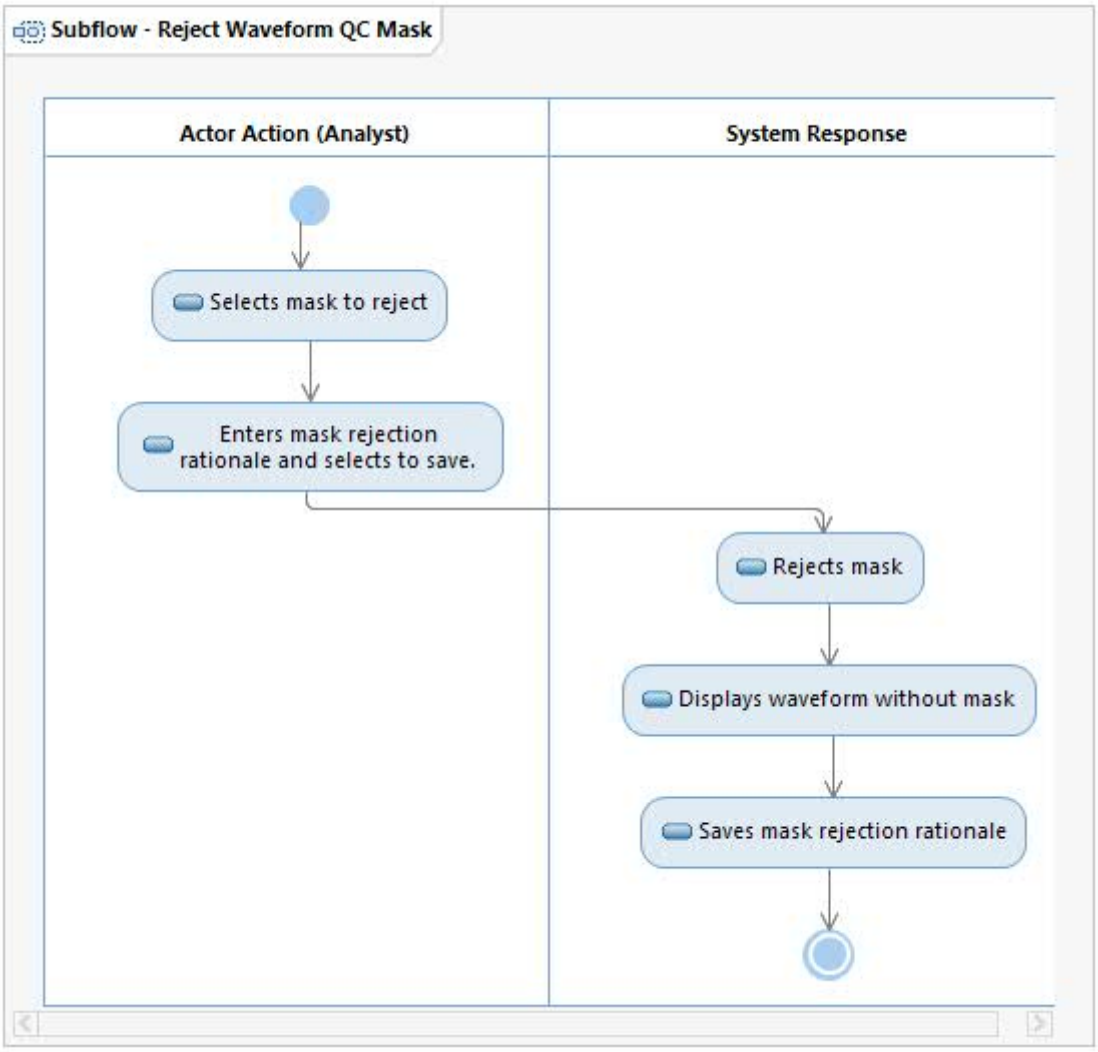
Action: "Saves mask"

The System saves the mask and the information about the mask creation, which includes:
- Date/time the mask was created
- Waveform the mask applies to
- Who created the mask

Alternate Flows

1. Action "Enters mask creation criteria and selects to save" - if the actor is an authorized user, a channel mask can be created, i.e., the end time selected can be in the future.

Subflow - Reject Waveform QC Mask



Action Descriptions

Action: "Selects mask to reject"

The Analyst selects the mask to reject which is displayed on the waveform segment the mask applies to.

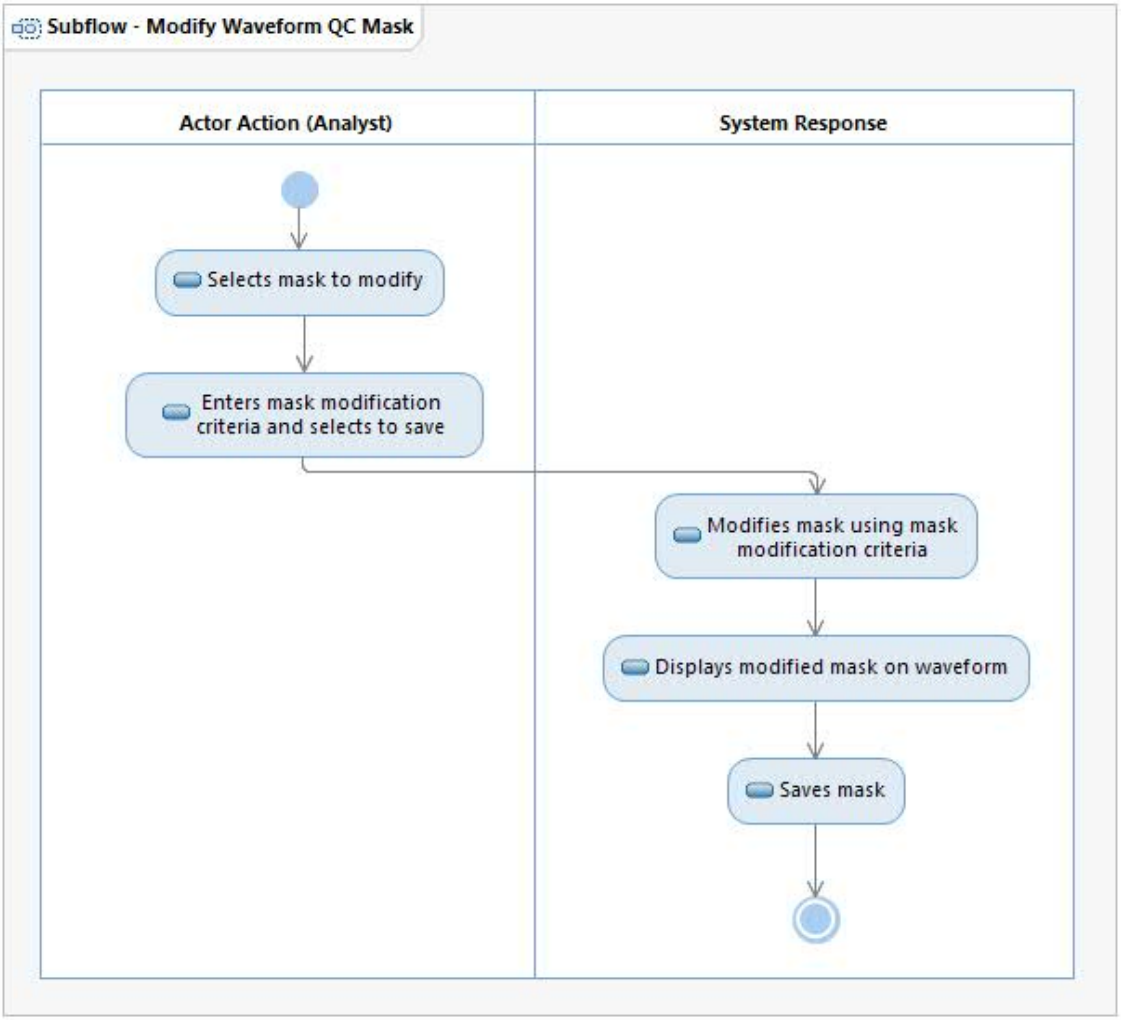
Action: "Saves mask rejection rationale"

The System saves information about why the mask was rejected which includes:
- Rationale for rejecting the mask
- Date/time the mask was rejected
- Waveform from which the mask was rejected
- Who rejected the mask

Alternate Flows

None.

Subflow - Modify Waveform QC Mask



Action Descriptions

Action: "Selects mask to modify"

The Analyst's selection of the mask to modify includes selection of the waveform the mask applies to.

Action: "Enters mask modification criteria and selects to save"

The Analyst enters the information about the modified mask which could include:
- Mask start time
- Mask end time
- Mask type
- Mask rationale

Action: "Saves mask"

The System saves the mask, including the history of all the masks that have been modified for a particular waveform segment.
The information includes:
- Date/time the mask was modified

- Waveform the mask applies to
- Who modified the mask

Alternate Flows
None.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1272: [*Threshold*] The System shall create Waveform QC Masks with times in the future.

S-1284: [*Threshold*] The System shall provide the Analyst the capability to view Waveform QC Masks.

S-1285: [*Threshold*] The System shall provide the Analyst the capability to view the Waveform QC Masks that were active at a user specified date and time.

S-1286: [*Threshold*] The System shall provide the Analyst the capability to create a Waveform QC Mask for a selected channel and time interval.

S-1287: [*Threshold*] The System shall provide the Analyst the capability to modify Waveform QC Masks.

S-1288: [*Threshold*] The System shall provide the Analyst the capability to reject Waveform QC Masks.

S-1289: [*Threshold*] The System shall provide the Analyst the capability to enter rationale for creating a Waveform QC Mask.

S-1290: [*Threshold*] The System shall provide the Analyst the capability to enter rationale for modifying a Waveform QC Mask.

S-1291: [*Threshold*] The System shall provide the Analyst the capability to enter rationale for removing a Waveform QC Mask.

S-1294: [*Threshold*] The System shall provide an authorized System User the capability to create a Waveform QC Mask extending into the future.

S-1296: [*Threshold*] The System shall store the processing time period(s) during which each Waveform QC Mask was applied to the underlying waveform data.

S-1297: [*Threshold*] The System shall store the Waveform QC Masks applied to the waveform data used for each waveform processing operation.

S-1298: [*Threshold*] The System shall store the channel masked by each Waveform QC Mask.

S-1299: [*Threshold*] The System shall store the identity of the user or processing stage creating each Waveform QC Mask.

S-1300: [*Threshold*] The System shall store the identity of the user or processing stage modifying each Waveform QC Mask.

S-1301: [*Threshold*] The System shall store the identity of the user or processing stage removing each Waveform QC Mask.

S-1302: [*Threshold*] The System shall store the time of each Waveform QC Mask creation.

S-1303: [*Threshold*] The System shall store the time of each Waveform QC Mask removal.

S-1304: [*Threshold*] The System shall store the time of each Waveform QC Mask modification.

S-1306: [*Threshold*] The System shall store the Analyst's rationale for creating a Waveform QC Mask.

S-1307: [*Threshold*] The System shall store the Analyst's rationale for modifying a Waveform QC Mask.

S-1308: [*Threshold*] The System shall store the Analyst's rationale for removing a Waveform QC Mask.

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-5582: [*Threshold*] The System shall provide the System User the capability to view the authentication status of waveform data.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Channel Mask - A type of Waveform Quality Control (QC) Mask (see Waveform QC Mask) that is created on a data channel for a period of time that can extend into the future, for instance

for channels that have known, continuing data quality issues. Only authorized users can create channel masks.

Data Quality Errors - Errors in waveforms that can lead to problems with processing and analysis. Data quality errors include data gaps, amplitude spikes, repeated amplitude values, linear trends, and invalid gain. Prior to signal processing, data are analyzed by quality control (QC) software to identify and record any errors (see Waveform QC Mask).

QC Mask - See waveform QC mask.

Quality Control (QC) - See waveform quality control.

Random Binary Calibration - A method to determine the frequency response of a sensor using a random binary signal applied to the sensor calibrator input. A random binary signal is a sequence of step functions of identical amplitude but randomly varying polarity. The random binary signal may be a known signal or may be recorded as an independent channel at the sensor. The sensor frequency response is calculated using the cross-spectrum of the sensor output to the input random binary signal.

Waveform - A generic term for either a raw waveform (see waveform, raw) or a derived waveform (see waveform, derived).

Waveform QC Mask - The tag applied to a segment of waveform data with a QC (see waveform quality control) problem. Each QC mask includes a start and stop time and a description of the type of problem. Subsequent waveform processing algorithms may use this information to mask (i.e., ignore) these segments.

Waveform Quality Control - The processing of waveform data to identify problems related to data acquisition and/or transfer (e.g., dropouts, spikes). In particular, waveform quality control is focused on identifying problems that can lead to false signal detections and/or to missed true signal detections.

IDC Specific:
None.

NOTES

General:
1. When an Analyst creates, modifies or rejects waveform QC masks, current processing results may be inconsistent with the masked waveforms. The System does not immediately reprocess the waveforms and recalculate dependent processing results. The Analyst can request the System reprocess data affected by the modified mask immediately, or the System may be configured to reprocess affected data in a subsequent automatic processing stage.

2. The history of all masks applied to a waveform is saved.

3. Although this Use Case does not store data, this Use Case maps to storage specifications because it creates data that are stored in other Use Cases. See 'Refines Event' UC.

IDC Specific:
None.

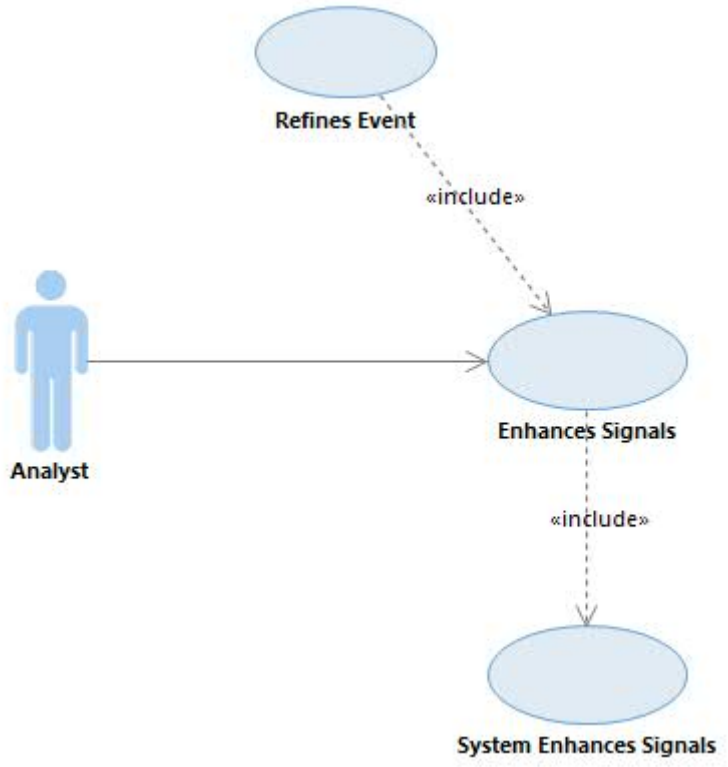
OPEN ISSUES

None.

IDC Use Case Report

UC-03.02.02 Enhances Signals

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the Analyst processes waveforms to enhance event signals while suppressing background noise. The Analyst enhances signals using the same algorithms as pipeline processing (see 'System Enhances Signals' UC), but the Analyst has the option to select the input parameters rather than using the predefined parameters used during pipeline processing.

ACTOR DESCRIPTIONS

Analyst - The Analyst is a System User who analyzes events. This actor includes all the traditional analysis roles. Any Analyst can access all System event analysis capabilities from a use case perspective. Individual analyst capabilities may be further specified by operations procedures.

PRECONDITIONS

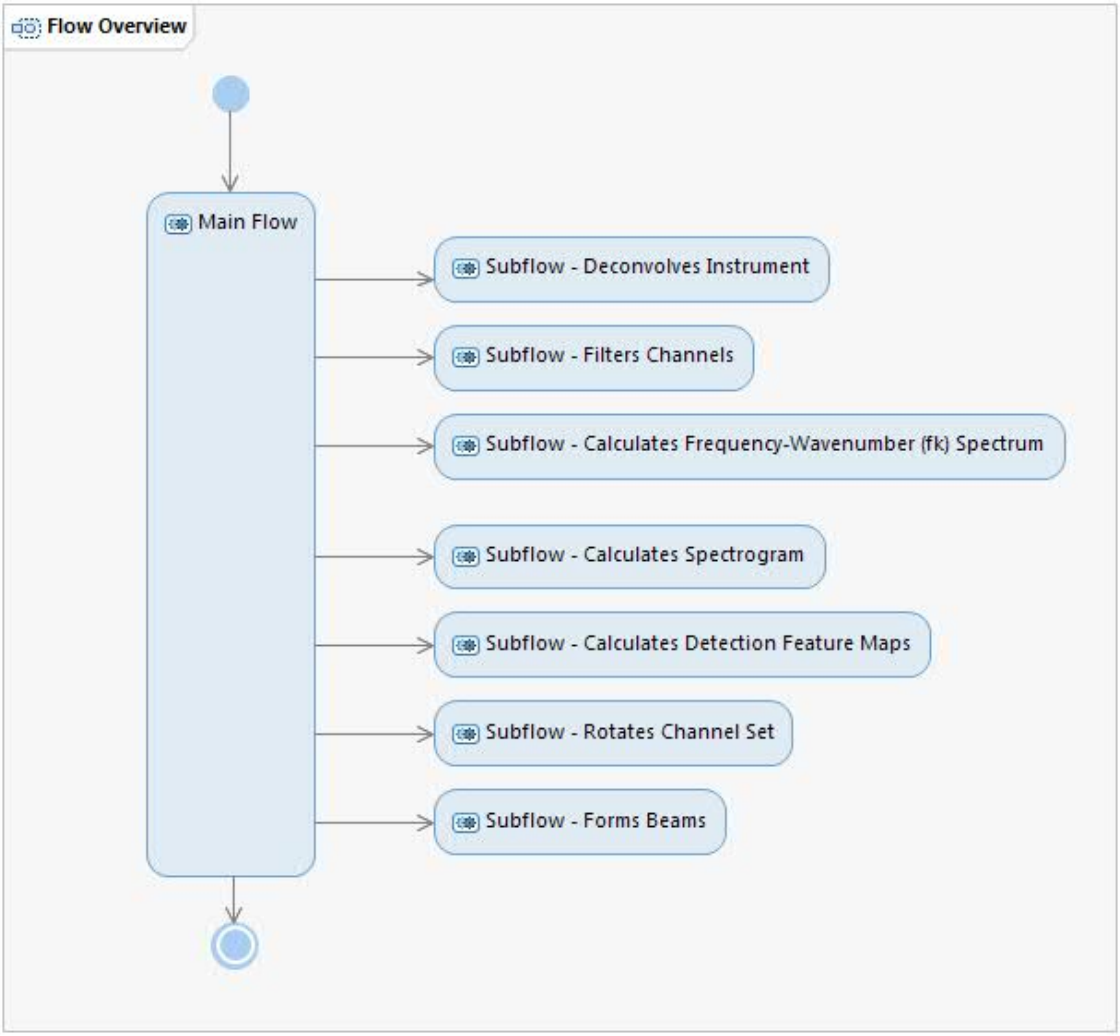
None.

POSTCONDITIONS

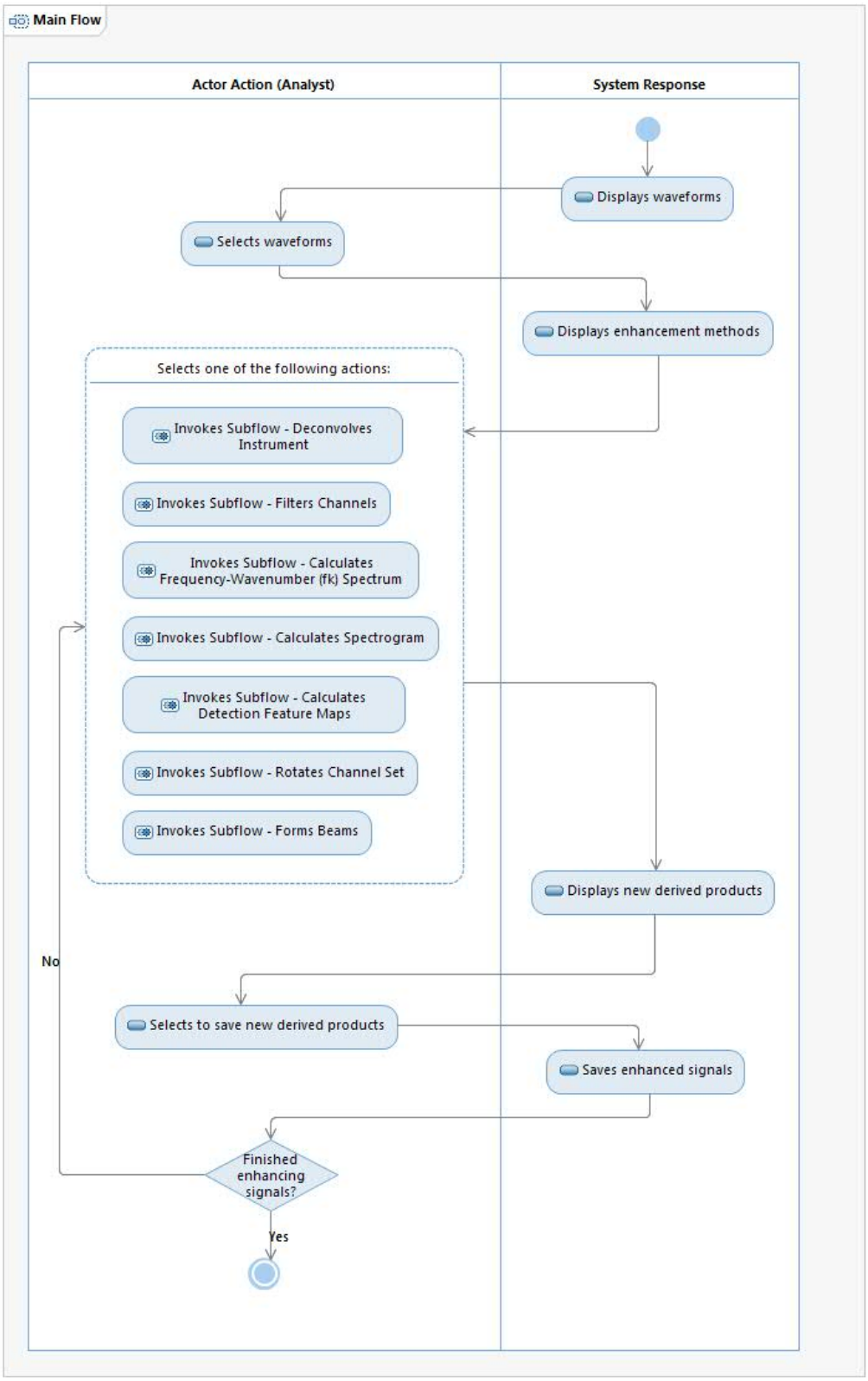
1. The derived waveforms as well as the filter parameters, rotation parameters, and beam parameters applied to each waveform, along with the order in which they were applied, are updated to support provenance of signal detections, event hypotheses, and other calculations subsequently made on the enhanced waveforms.

ACTIVITY DIAGRAMS

Flow Overview



Main Flow



Action Descriptions

Action: "Displays waveforms"

The System displays raw and derived (e.g., filtered, rotated, beamed) waveforms, including continuous beams.

When this use case is invoked, the System displays:
1. All raw and filtered waveforms with signal detections associated with the event hypothesis.

2. All rotated or beamed waveforms targeting the event hypothesis, whether or not the waveforms have signal detections associated to the event hypothesis. Multiple origin beams could target the same event hypothesis location if those origin beams have different phases.

Action: "Selects waveforms"
The Analyst selects waveforms with signals to enhance and sets a time interval. For beaming, waveforms must come from the elements of an array. For rotation, waveforms must come from the channels of a station. For filtering, there are no constraints on waveform selection.

Action: "Displays enhancement methods"
The System displays available enhancement options such as deconvolve, filter, rotate, beam, and detection feature maps.

Action: "Displays new derived products"
The System displays new, derived products created by the signal enhancement operation and updates previously displayed products modified by the signal enhancement operation.

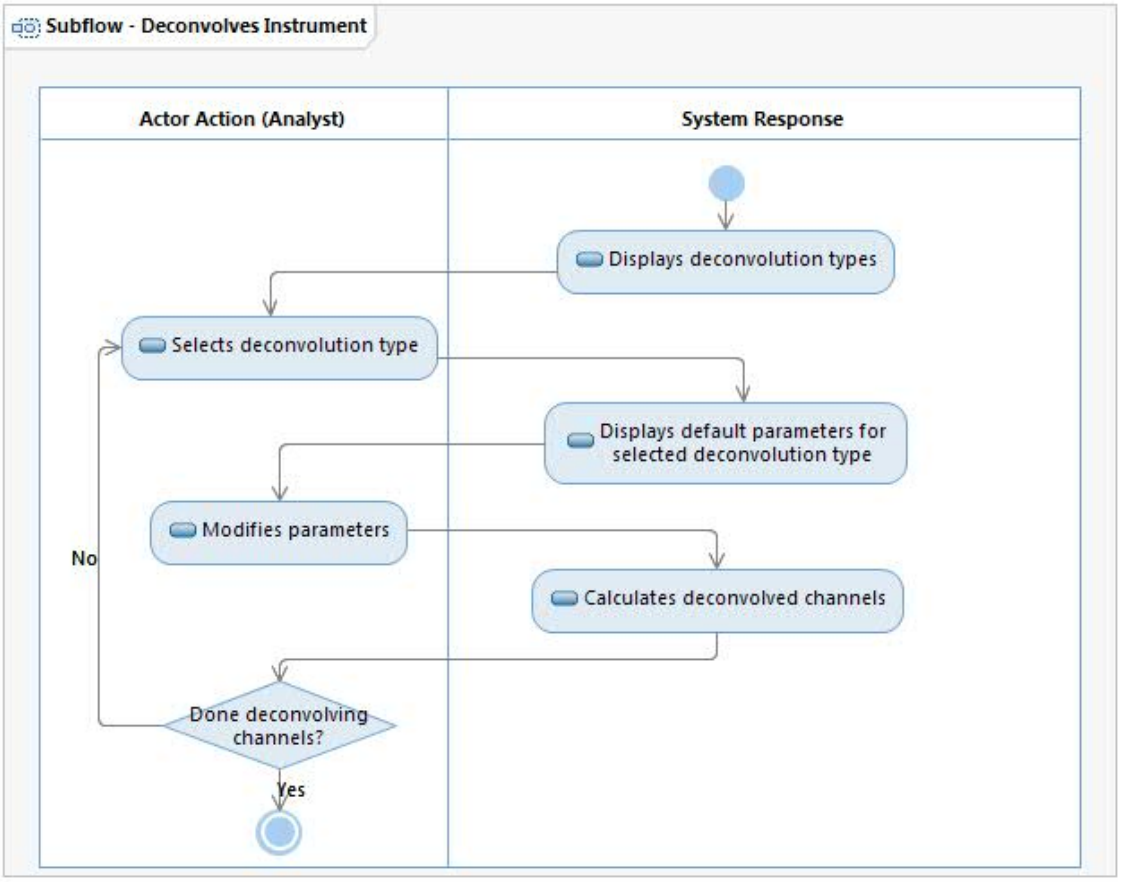
Action: "Selects to save new derived products"
The Analyst may save any derived waveform products they create that have no associated signal detections or events.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to 'Refines Event' UC.

2. Analyst Action "Selects to save enhanced signals" - The Analyst may choose not to save, in which case, flow proceeds to "Finished enhancing signals?"

3. Action "Invokes Subflow – Filters Channels" - This use case may begin at this step when included from 'Scans Waveforms and Unassociated Detections' UC.

Subflow - Deconvolves Instrument



Action Descriptions

Action: "Displays deconvolution types"

The System displays deconvolution methods.

Action: "Displays default parameters for selected deconvolution type"

The System displays the default parameters for the selected deconvolution type, including the instrument response. The default parameters are configured by the System Maintainer (see 'Configures Processing Components' UC) and can be overridden by the Analyst.

Action: "Modifies parameters"

The Analyst overrides the default parameters.

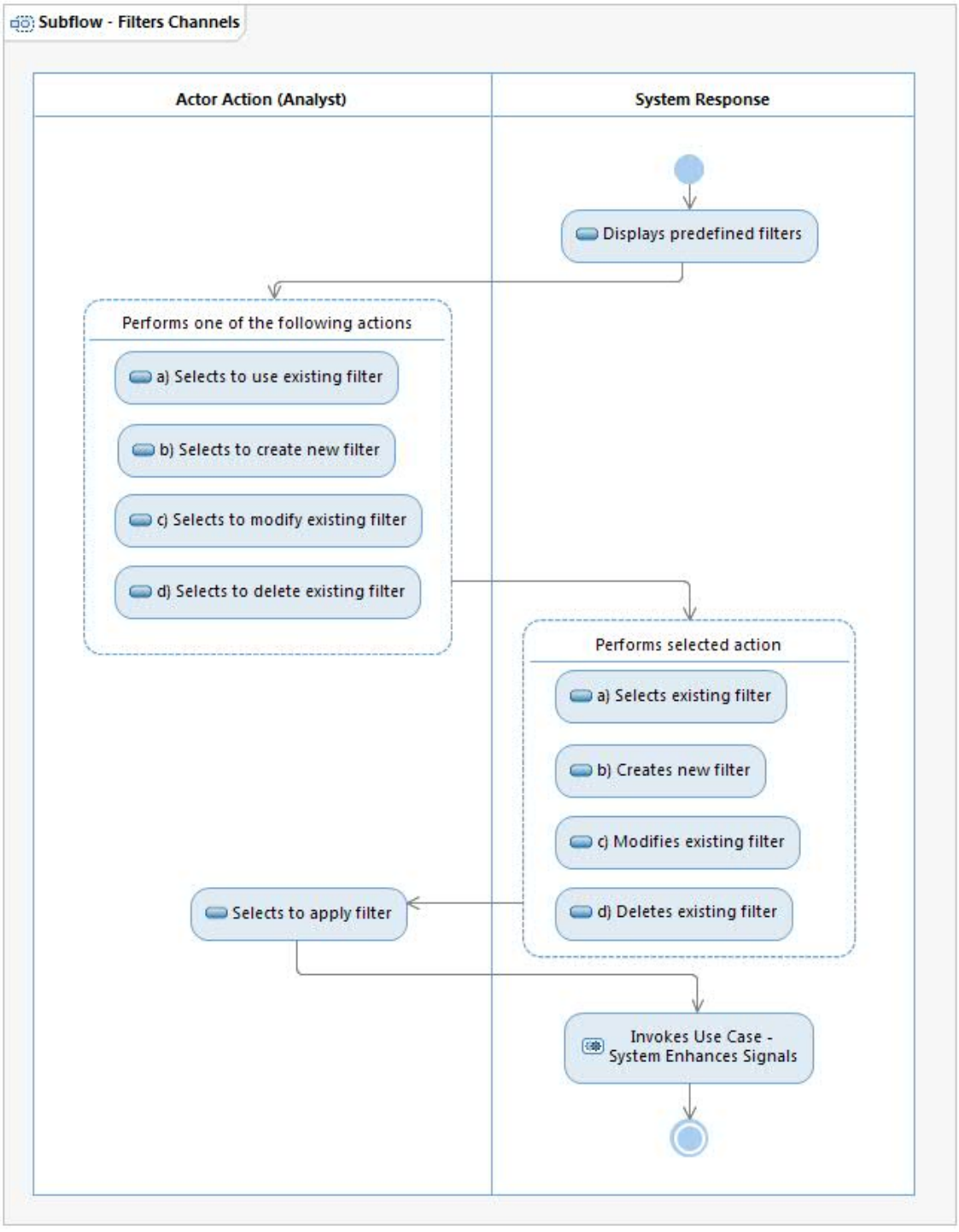
Alternate Flows

1. Any Actor Action - The Analyst may choose to cancel, in which case this subflow ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

3. Action "Calculates deconvolved waveforms" - The System may determine the waveforms cannot be deconvolved, in which case the Analyst is notified and this subflow ends, and returns to the Main Flow.

Subflow - Filters Channels



Action Descriptions

Action: "Displays predefined filters"

The System displays a list of predefined filters and their parameters. Predefined filters are configured by the System Maintainer (see 'Configures Processing Components' UC).

When a filter is already applied to the selected channels, the System indicates that filter in the filter list and displays that filter's parameters.

The System Maintainer configures the station-specific default filters as well as a specific list of filters applicable to different stations (see 'Configures Processing Components' UC). The list of default filters dynamically adjusts as necessary (e.g., in response to a change in event location and depth).

Action: "a) Selects to use existing filter"
The Analyst selects a filter that has been defined within the System or is available within the Analyst's filter list.

Action: "b) Selects to create new filter"
The Analyst designs the filter and specifies the filter parameters using the filter and filter cascade design options provided by the System. The Analyst may save the filter, including a textual description.

Action: "c) Selects to modify existing filter"
The Analyst modifies the filter and filter parameters using the filter and filter cascade design options for existing filters provided by the System. If the selected filter is a filter cascade, the Analyst modifies one or more of the filters in the filter cascade. The Analyst may save the modified filter, including a textual description.

Action: "d) Selects to delete existing filter"
The Analyst selects to delete the filter from the Analyst's filter list.

Action: "a) Selects existing filter"
The System displays and highlights the filter selected by the Analyst and its parameters in the filter list.

Action: "b) Creates new filter"
The System displays and highlights the new filter created by the Analyst and its parameters in the filter list. If the Analyst saves the newly created filter, the System will add the filter to the Analyst’s filter list. These Analyst-specific filters are saved with the event's history if those filters are used when building an event. (Permanently adding a filter to the list of System-wide filters is done by the System Maintainer in 'Configures Processing Components' UC.) .

Action: "c) Modifies existing filter"
The System displays and highlights the modified filter and its parameters in the filter list. If the Analyst saves the newly created filter, the System will add the filter to the Analyst’s filter list. These Analyst-specific filters are saved with the event's history if those filters are used when building an event. (Permanently adding a filter to the list of System-wide filters is done by the System Maintainer in 'Configures Processing Components' UC.)

Action: "d) Deletes existing filter"

The System deletes the filter from the Analyst's filter list. (Permanently deleting a filter from the list of System-wide filters is done by the System Maintainer in 'Configures Processing Components' UC.)

Action: "Selects to apply filter"
The Analyst selects to apply the selected, created, or modified filter to the selected channels.

Action: "Invokes Use Case - System Enhances Signals"
The System invokes the 'System Enhances Signals' UC to filter the selected channels with the Analyst provided filter, and filter parameters. This invoked use case applies the filters to the channels which creates a corresponding set of derived channels and associated group delays.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

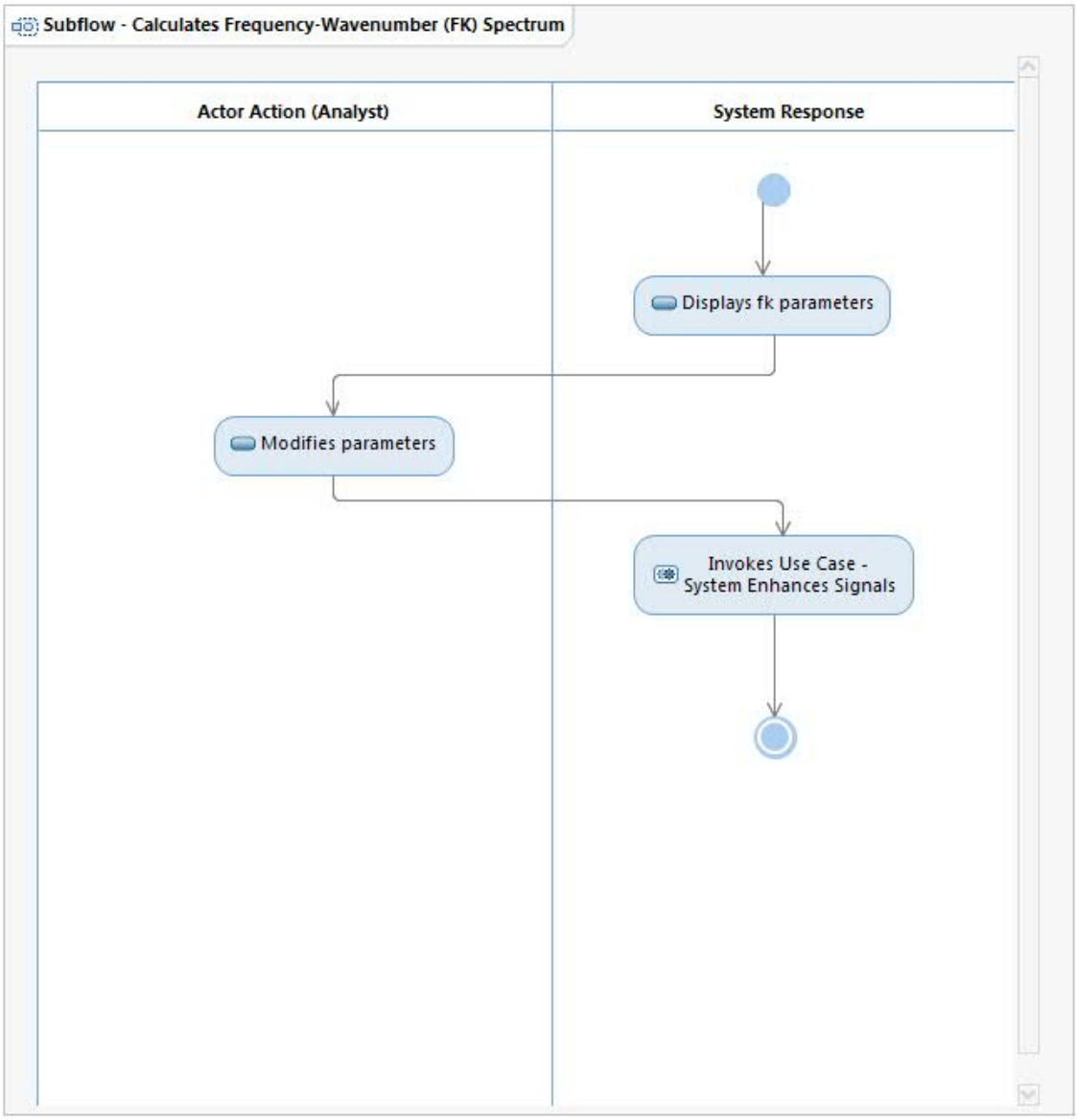
3. Action "Selects to use existing filter" - The Analyst may decide to return to the existing filter, in which case, flow proceeds to Action "Invokes Use Case - System Enhances Signals" using the channels' previous filter and filter parameters.

4. Action "Invokes Use Case - System Enhances Signals" - The System may determine a filter cannot be applied to the selected channels, in which case the Analyst is informed and this subflow ends, and returns to the Main Flow.

5. Action "Invokes Use Case - System Enhances Signals" - The System will not apply a specified filter to a specified input channel if the difference between the filter's sample rate and the channel's sample rate is greater than the filter's sample rate tolerance. In this case, the Analyst is informed and this subflow ends, and returns to the Main Flow.

6. Action "Applies filter" - If the Analyst deletes a filter, this subflow ends before this Action, and returns to the Main Flow.

Subflow - Calculates Frequency-Wavenumber (fk) Spectrum



Action Descriptions

Action: "Displays fk parameters"

The System displays a list of predefined parameters for computing the frequency-wavenumber (fk) spectrum.

Action: "Modifies parameters"

The Analyst modifies the fk parameters.

Action: "Invokes Use Case - System Enhances Signals"

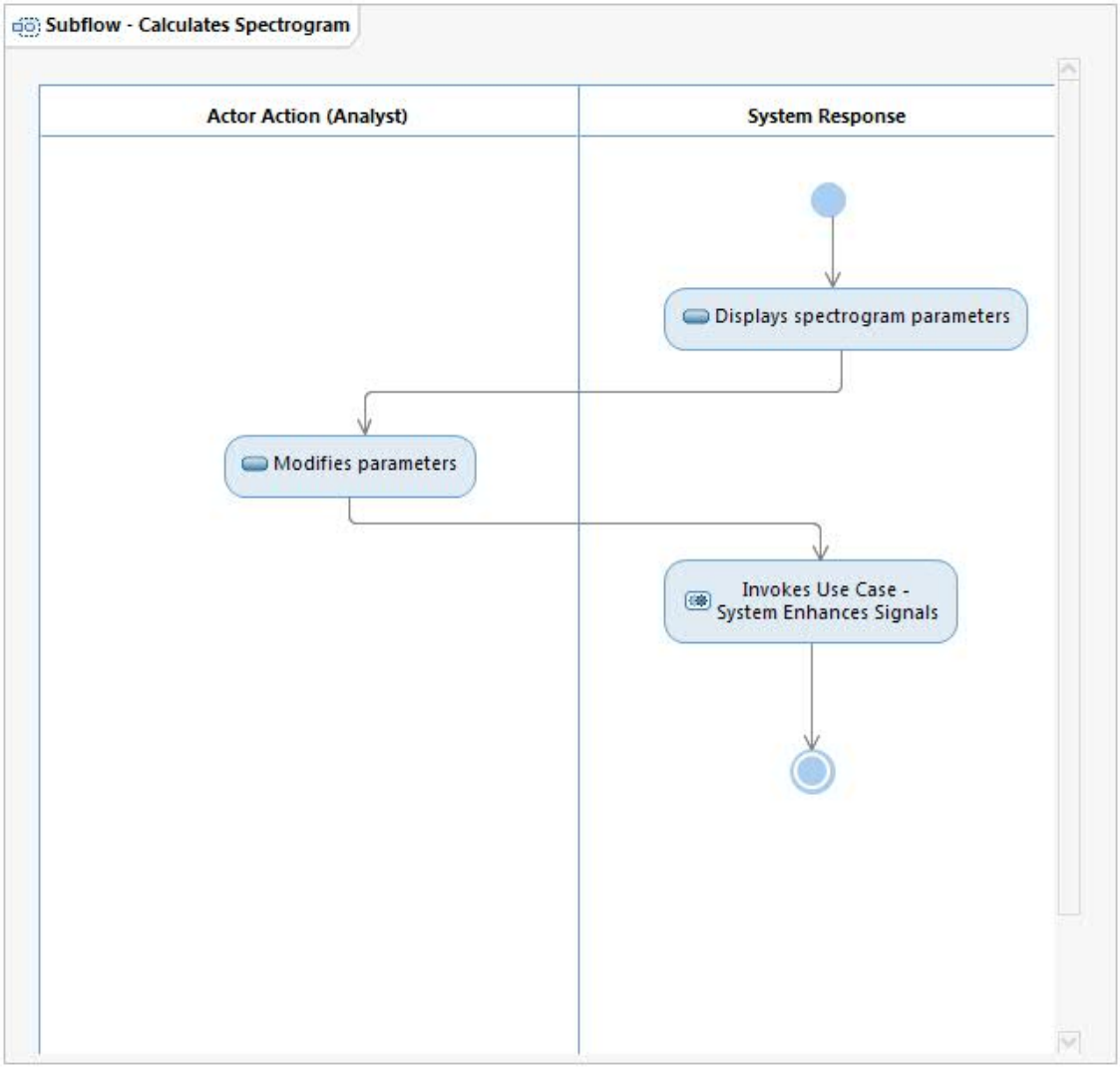
The System invokes the 'System Enhances Signals' UC to calculate the frequency-wavenumber (fk) spectrum with the modified parameters.

Alternate Flows

1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

Subflow - Calculates Spectrogram



Action Descriptions

Action: "Displays spectrogram parameters"

The System displays a list of predefined parameters for computing spectrograms

Action: "Modifies parameters"

The Analyst modifies the spectrogram parameters.

Action: "Invokes Use Case - System Enhances Signals"

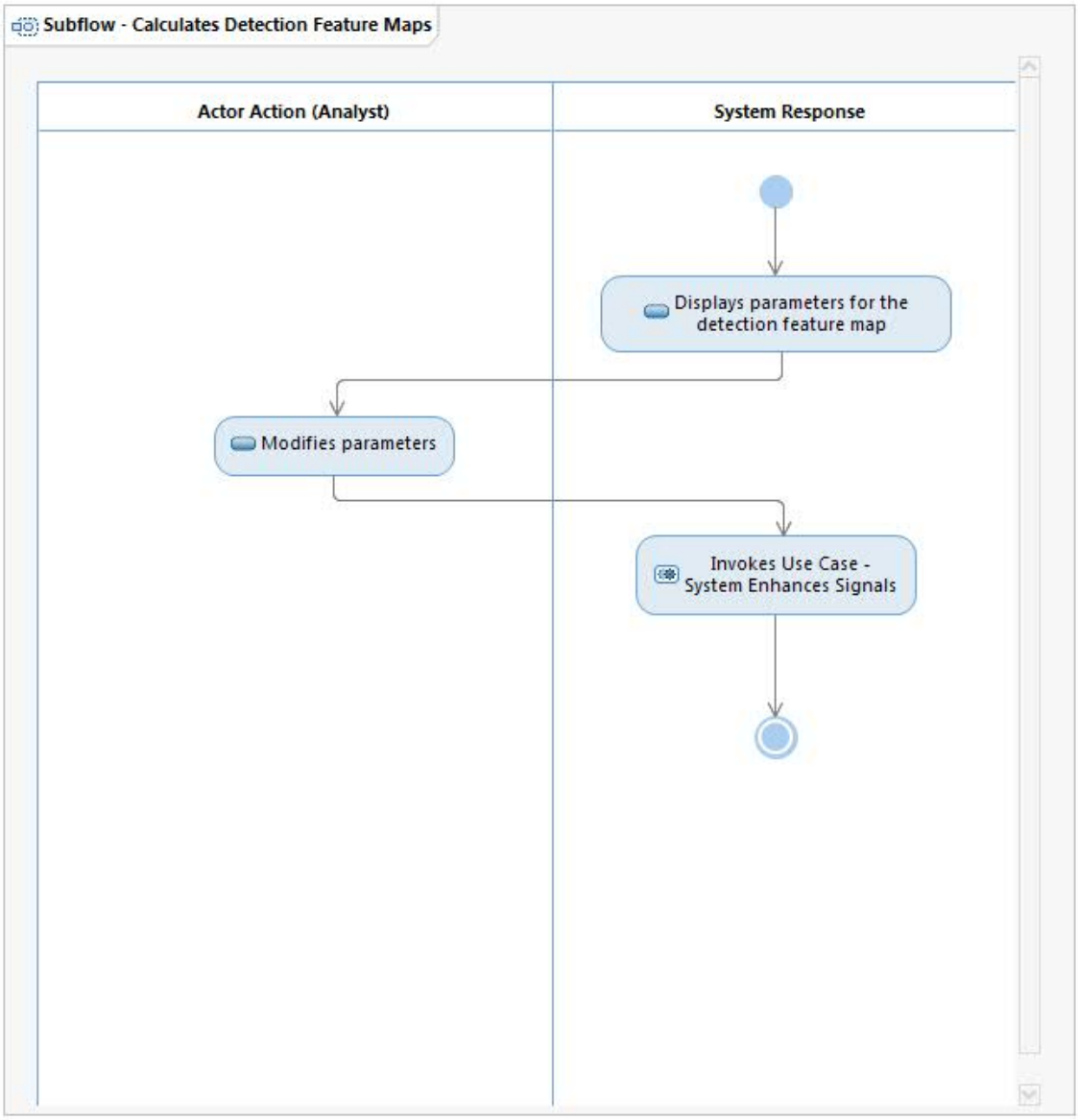
The System invokes the 'System Enhances Signals' UC to calculate the spectrogram with the modified parameters.

Alternate Flows

1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

Subflow - Calculates Detection Feature Maps



Action Descriptions

Action: "Displays parameters for the detection feature map"

The System displays a list of predefined parameters for computing the detection feature map.

Action: "Modifies parameters"

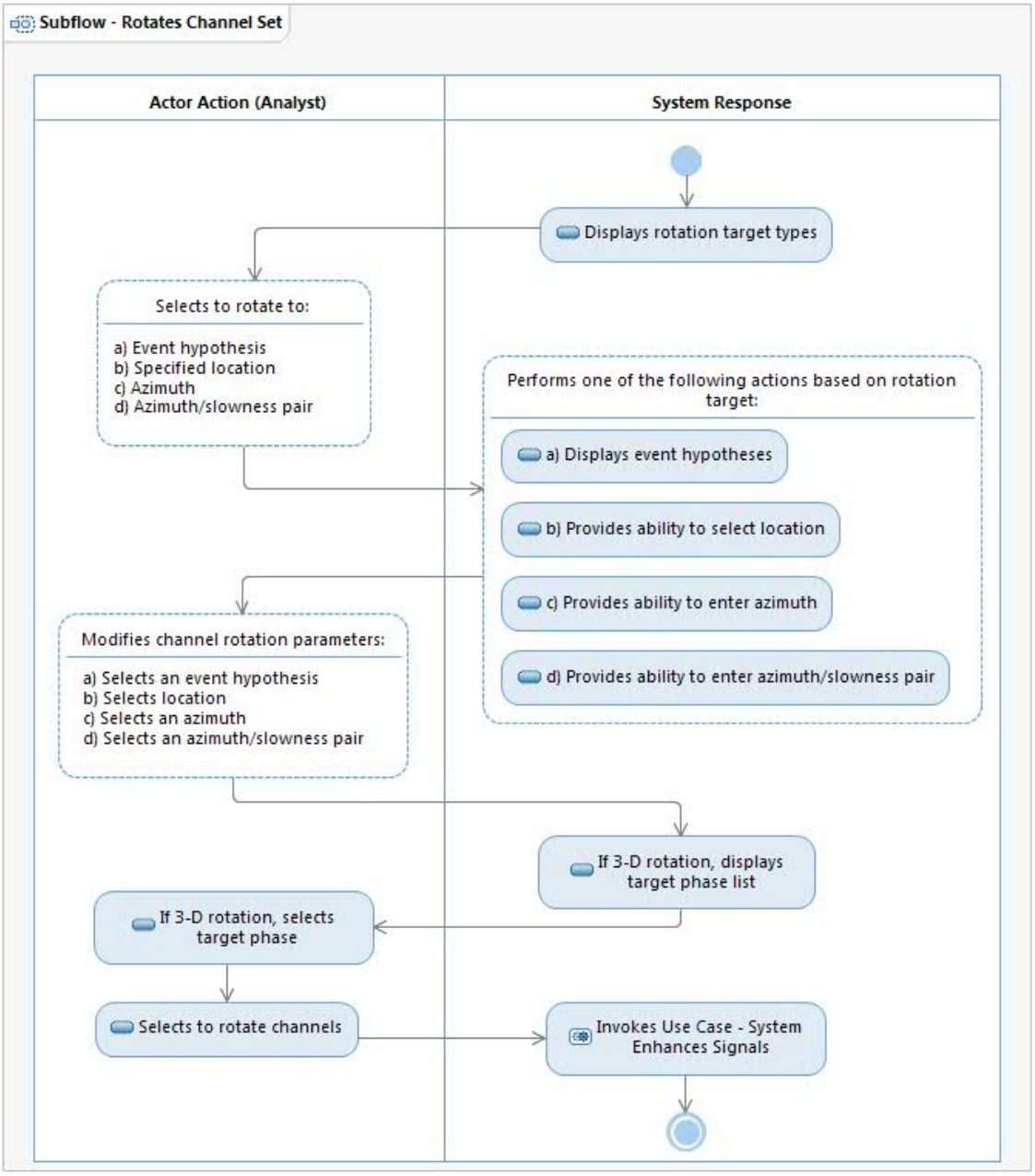
The Analyst modifies the parameters for the detection feature map.

Action: "Invokes Use Case - System Enhances Signals"
The System invokes the 'System Enhances Signals' UC to calculate the detection feature map with the modified parameters.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

Subflow - Rotates Channel Set



Action Descriptions

Action: "Selects to rotate to:"

The Analyst selects to rotate to an event hypothesis, a specified location, an azimuth (for 2-D rotation), or an azimuth/slowness pair (for 3-D rotation). The Analyst also selects if the rotation will be two dimensional (rotate horizontal components to a target azimuth) or three dimensional (radial and transverse rotation to target signals arriving at a specific azimuth and angle of incidence).

Action: "a) Displays event hypotheses"

The System displays a list of existing event hypotheses that have the potential to have signal detections on the channels being rotated. If the selected channels are already rotated to an event hypothesis, the System indicates the corresponding event hypothesis.

The System Maintainer configures default rotation target sets (see 'Configures Processing Components' UC).

Action: "b) Provides ability to select location"
The System provides the ability to select the rotation target location (e.g., graphical, map, coordinates). If the selected channels are already rotated to target a location, the System indicates the location.

The System Maintainer configures default rotation target sets (see 'Configures Processing Components' UC).

Action: "If 3-D rotation, displays target phase list"
The System displays a list of phases that can be targeted during channel rotation.

Action: "If 3-D rotation, selects target phase"
The Analyst selects the phase to target with the rotated channels.

Action: "Invokes Use Case - System Enhances Signals"
The System invokes the 'System Enhances Signals' UC to rotate the selected channels (channel set and time interval) with the Analyst provided rotation type, rotation parameters, and target phase. The invoked use case rotates the channels of the specified 3-component station to a coordinate system aligned to a specified azimuth and slowness pair resulting in a set of derived channels.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this subflow ends, and returns to the Main Flow.

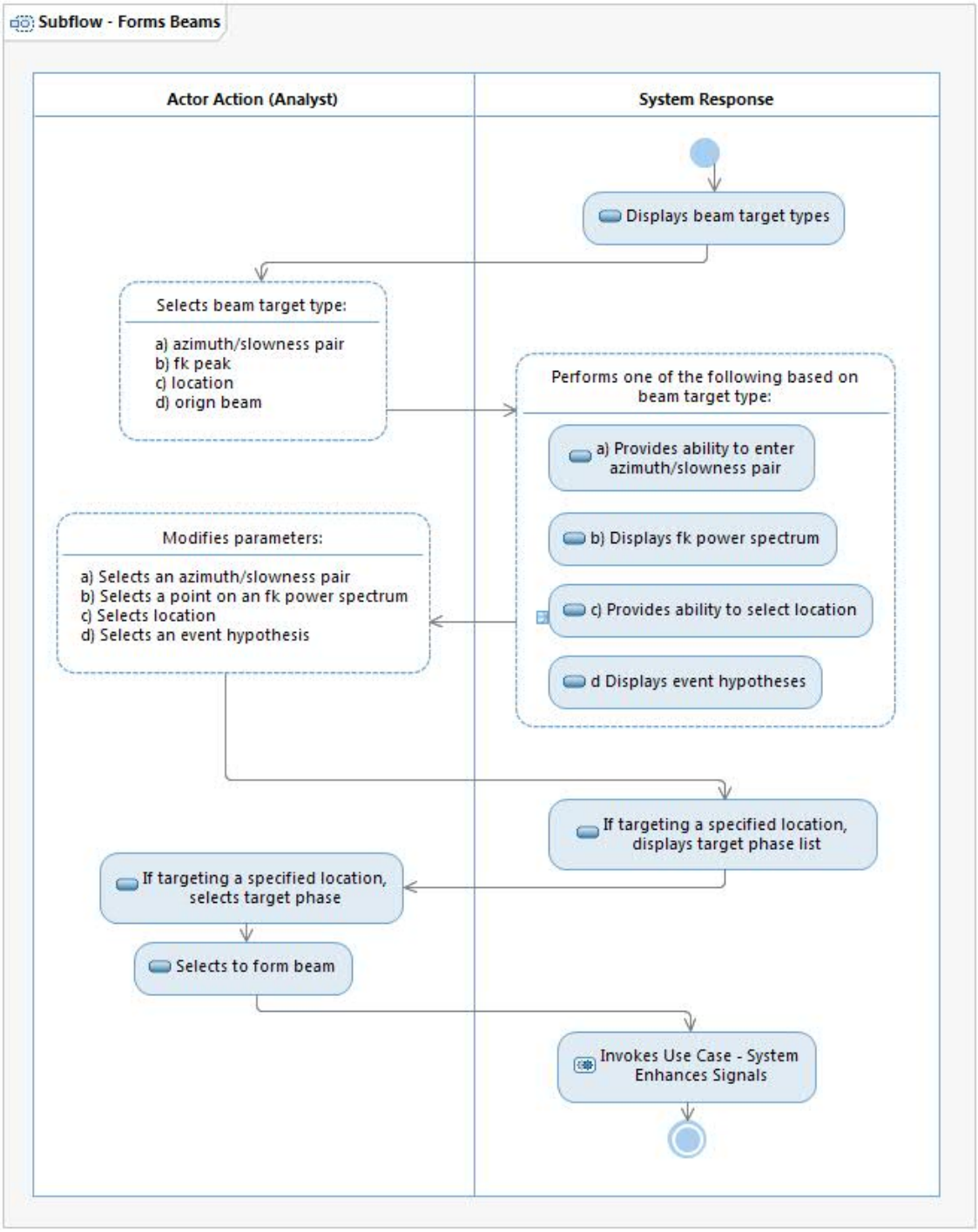
2. Any Actor Action - The Analyst may undo/redo previous actions.

3. Action "Selects to rotate to:" - When the selected channels are already rotated to an event hypothesis, the Analyst may decide to recreate the rotation without adjusting any parameters, in which case, flow proceeds to Action "Invokes Use Case - System Enhances Signals". This rotation recalculation might be done when the event hypothesis location has changed.

4. Action "If 3-D rotation, selects target phase" - The Analyst may choose to target the default phase rather than selecting a target phase, in which flow proceeds to Action "Selects to rotate channels". The System Maintainer configures the default phases targeted by channel rotation (see 'Configures Processing Components' UC).

5. Action "Invokes Use Case - System Enhances Signals" - The selected channels may not be able to be rotated, in which case this subflow ends, and returns to the Main Flow.

Subflow - Forms Beams



Action Descriptions

Action: "Displays beam target types"

The System displays a list of beam target types. If the selected channels are already beamed, the System indicates their beam type.

Action: "Selects beam target type:"

The Analyst selects the beam target:

a) Selecting an azimuth/slowness pair allows creating detection beams
b) Selecting an fk peak targets the maximum fk power spectrum direction (azimuth and slowness) in 2D fk space corresponding to a signal detection
c) Selecting location targets any geographic location (either continuously as a virtual origin beam or as a virtual origin)
d) Selecting an event hypothesis location beam targets an existing event hypothesis location

Action: "b) Displays fk power spectrum"
The System displays the fk power spectrum and fk power statistic for the channels being beamed for the selected time interval. The System indicates the peak in the fk power spectrum. If the channels selected by the Analyst are an fk beam, the System displays the corresponding fk power spectrum and F-statistic.

The System Maintainer configures default beam sets (see 'Configures Processing Components' UC).

Action: "Modifies parameters:"
The Analyst modifies the beam parameters (e.g., whether to form coherent or incoherent beams, any filtering that needs to be done on the beam, frequency domain or time domain, whether or not resampling is needed) for the selected beam target.

Action: "c) Provides ability to select location"
The System provides the ability to select the beam target location (e.g., graphical, map, coordinates). If the selected channels are already beamed to target a location, the System displays the location.

The System Maintainer configures default rotation target sets (see 'Configures Processing Components' UC).

Action: "d Displays event hypotheses"
The System displays a list of existing event hypotheses that have the potential to have signal detections on the channels being beamed. If the selected channels are an origin beam, the System highlights the corresponding event hypothesis.

The System Maintainer configures default beam sets (see 'Configures Processing Components' UC).

Action: "If targeting a specified location, displays target phase list"
If the Analyst is creating an origin beam, the System displays a list of phases that can be targeted by origin beams.

Action: "If targeting a specified location, selects target phase"
If the Analyst is creating an origin beam, the Analyst selects the origin beam's target phase.

Action: "Invokes Use Case - System Enhances Signals"
The System invokes the 'System Enhances Signals' UC to form a beam from the selected channels (channel set for a single array and time interval) with the Analyst provided beam type and beam parameters, including azimuth/slowness pairs. The invoked use case creates a set of derived waveforms containing summed time series samples across the array elements for each ground motion component.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this subflow ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

3. Action "Displays beam target types" - The System may determine the channels cannot be beamed, in which case the Analyst is notified and this subflow ends, and returns to the Main Flow.

4. Action "Selects beam target type" - When the selected channels are already an origin beam, the Analyst may decide to recreate the beam without adjusting any parameters, in which case, flow proceeds to Action "Invokes Use Case - System Enhances Signals". This beaming recalculation might be done with the event hypothesis location has changed.

5. Action "Modifies parameters" - The Analyst may adjust the time interval for computing the fk power spectrum, in which case, flow returns to the Action "Display fk power spectrum".

6. Action "Modifies parameters" - The Analyst may apply a filter to the fk power spectrum to block energy from a user specified azimuth and slowness, in which case, flow returns to the Action "Displays fk power spectrum".

7. Action "If origin beam, selects target phase" - The Analyst may choose to target the default phase rather than selecting a target phase, in which case, flow proceeds to Action "Selects to form beam". The System Maintainer configures the default phases that beams target (see 'Configures Processing Components' UC).

8. Action "Invokes Use Case - System Enhances Signals" - The System notifies the Analyst when the channels selected for a beam have sample rates that differ by more than the beam's sample rate tolerance or when the channels selected for a beam measure inconsistent types of ground motion. The System resamples the channels and/or converts the channels to a common type of ground motion, and the use case continues.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1319: [*Threshold*] The System shall convert analog filter transfer functions to digital filter transfer functions.

S-1334: [*Threshold*] The System shall provide the Analyst the capability to design a Butterworth filter.

S-1335: [*Threshold*] The System shall provide the Analyst the capability to design a Pseudo Correlation filter.

S-1336: [*Threshold*] The System shall provide the Analyst the capability to design a Phase Match filter.

S-1337: [*Threshold*] The System shall provide the Analyst the capability to design an autoregressive filter.

S-1338: [*Threshold*] The System shall provide the Analyst the capability to design a filter by directly specifying the coefficients of the numerator and denominator of the filter's transfer function.

S-1339: [*Threshold*] The System shall provide the Analyst the capability to enter textual descriptions for user designed waveform filters.

S-1340: [*Threshold*] The System shall provide the Analyst the capability to view filtered waveforms.

S-1341: [*Threshold*] The System shall provide the Analyst the capability to view predefined waveform filter parameters.

S-1342: [*Threshold*] The System shall provide the Analyst the capability to apply predefined filters to selected waveforms.

S-1343: [*Threshold*] The System shall provide the Analyst the capability to design filter cascades.

S-1344: [*Threshold*] The System shall notify the Analyst when a filter is not applied to a waveform because the difference between the filter's sample rate and the waveform's sample rate is greater than the filter's sample rate tolerance.

S-1346: [*Threshold*] The System shall store a textual description with each waveform filter.

S-1347: [*Threshold*] The System shall store filters using the coefficients of the numerator and denominator of the filter's transfer function.

S-1352: [*Threshold*] The System shall provide the Analyst the capability to rotate the components of 3-component seismic waveform data to any Analyst specified 3-dimensional coordinate system.

S-1353: [*Threshold*] The System shall provide the Analyst the capability to rotate the components of 2-component horizontal seismic waveform data to any Analyst specified azimuth.

S-1370: [*Threshold*] The System shall notify the Analyst when the channels selected for a beam measure inconsistent types of ground motion.

S-1371: [*Threshold*] The System shall notify the Analyst when any two channels selected for a beam have sample rates that differ by more than the beam's sample rate tolerance.

S-1373: [*Threshold*] The System shall provide the Analyst the capability to view continuous beams for virtual event hypotheses for predefined geographic regions.

S-1374: [*Threshold*] The System shall provide the Analyst the capability to view beam parameters.

S-1375: [*Threshold*] The System shall provide the Analyst the capability to select channels included in a beam from a subset of configured channels.

S-1376: [*Threshold*] The System shall provide the Analyst the capability to create beams for a user specified time interval.

S-1377: [*Threshold*] The System shall provide the Analyst the capability to create beams for a user specified azimuth and slowness selected from an fk spectra.

S-1378: [*Threshold*] The System shall provide the Analyst the capability to create beams for a user specified event hypothesis and phase.

S-1379: [*Threshold*] The System shall provide the Analyst the capability to create beams for a user specified hypocenter (latitude, longitude, depth) and phase.

S-1380: [*Threshold*] The System shall provide the Analyst the capability to form coherent beams.

S-1381: [*Threshold*] The System shall provide the Analyst the capability to form incoherent beams.

S-1382: [*Threshold*] The System shall provide the Analyst the capability to create beams for a user specified/selected point in slowness space.

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2099: [*Threshold*] The System shall provide the System User the capability to view spectrograms for any channel.

S-2100: [*Threshold*] The System shall provide the System User the capability to select the parameters used to calculate spectrograms per channel.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-2420: [*Threshold*] The System shall provide the Analyst the capability to store selected derived waveforms.

S-5621: [*Threshold*] The System shall by default invoke the same algorithms during interactive processing as those used in automated processing.

S-5955: [*Threshold*] The System shall provide the Analyst the capability to view predefined filters.

S-5956: [*Threshold*] The System shall provide the Analyst the capability to save user designed filters.

S-6196: [*Threshold*] The System shall provide the Analyst the capability to select the dispersion model to be used for phase match filtering.

S-6198: [*Threshold*] The system shall provide the Analyst the capability to view a time-series of maximum F-statistic values for specified time windows.

S-6468: [*Threshold*] The System shall provide the Analyst the capability to create detection feature maps.

S-6469: [*Threshold*] The System shall store detection feature maps.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Azimuth - The angle in degrees measured clockwise from geographic North of a signal arriving at a station. Azimuth and slowness completely describe the vector direction of arrival for a signal at a station.

Beam - The product of beamforming; a single derived channel (see channel, derived) representing the sum of the raw channels (see channel, raw) for all the elements of an array.

Beam Steering - See beamforming (beaming).

Beam, Coherent - The derived channel (see channel, derived) resulting from coherent beamforming (see beamforming [beaming], coherent).

Beam, Continuous - A beam channel formed continuously in time (i.e., without any specified start or end time).

Beam, Detection - The beam on which a signal detection occurs. When detecting signals for data from an array, a set of beams is formed spanning the regions of monitoring interest. Detectors are run on all of these beams to look for signals. If a signal is detected, the beam on which the detection occurred is known as the detection beam. If there are detections on more than one beam, then the best of these will be selected (e.g., best SNR) as the detection beam.

Beam, Incoherent - The derived channel (see channel, derived) resulting from incoherent beamforming (see beamforming [beaming], incoherent).

Beam, Origin - A beam steered to the location of an event hypothesis. A particular phase (typically, first arriving P [compressional wave]) must be assumed for each origin beam. When an event hypothesis is displayed for an analyst to review, frequency-wavenumber (fk) beams are shown for detecting stations, and origin beams are shown for non-detecting stations. Assuming the Event hypothesis is well-located, the origin beams should allow the analyst to manually add any signal detections that were missed.

Beam, fk - A beam steered to point to the maximum fk power spectrum direction (azimuth and slowness) in 2D fk space (see frequency-wavenumber [fk]processing) corresponding to a signal detection on an array. The fk beam should show the best possible signal for a signal detection, and hence is the beam that is automatically shown to an analyst reviewing an event hypothesis.

Beamforming (Beaming) - Beamforming (also known as beaming) is a multichannel signal processing technique taking advantage of the direction-dependent arrival of a signal across an the elements of an array. Beamforming sums the waveform data from the elements of an array to produce a single derived channel (see channel, derived). The intent is to boost SNR.

Beamforming (Beaming), Coherent - A method for increasing the SNR of signals arriving at an array from a particular azimuth and slowness. Coherent beamforming (also known as beam steering) time shifts the waveforms from an array's elements before summing, under the assumption that a plane wave is arriving from that direction. The shifting is done for each element by subtracting the time delay relative to the array beampoint (a reference location for the array) that would be expected for a plane wave arriving from that azimuth and slowness. If there is a signal arriving from the specified azimuth and slowness, an SNR gain occurs when summing the time delayed waveforms, due to the simultaneous constructive interference of coherent directional signals, and destructive interference of incoherent background noise. In theory, a gain of SNR equal to the square root of the number of elements can be achieved (e.g., a factor of 3 for a 9 element array). In practice, the realized gain is usually less.

Beamforming (Beaming), Incoherent - The same as coherent beamforming except that the waveforms are rectified (i.e., absolute values) before summing.

Detection Feature Map - A matrix of values for a particular feature as measured at a particular station over time. The matrix contains a feature vector calculated for each point in time based on the processing of one or more waveforms from the station. The feature vector is a set of values indexed by secondary independent variables, for example, frequency. Detection feature maps are used to detect and identify signals. A spectrogram is an example of a detection feature map where the feature is signal amplitude and the index is frequency. Array coherence is another example where the feature is coherence (or another feature gated by a coherence threshold) and the index is frequency.

F-statistic (Fisher Statistic) - The power on a beam, divided by the average, computed over all the array elements of each element's residual power. The F-statistic can be used as the basis for a signal detector for data from an array or to characterize the coherence of the signal detection on a particular beam. Because each point in a frequency-wavenumber (fk) power spectrum corresponds to an azimuth and slowness pair, calculating an F-statistic for each point in the spectrum can help identify the peaks. See Blandford, "An automatic event detector at the Tonto Forest Seismic Observatory", Geophysics 39, (1974): 633-643.

Filter Cascade - The application of two or more waveform filters (see filter, waveform) in series. Complex filters can be designed to meet a set of specific needs by applying a series of simple filters, each of which is designed to meet a more basic need. Once the sequence of filters is known, the successive filter operations can be replaced with a single filter operation equivalent to the filter cascade.

Filter, Waveform - An algorithm that operates on a waveform to produce a derived waveform with enhanced signal content relative to the background. The most common type of filtering limits frequency content (e.g., low-pass, high-pass, or band-pass). More complex types of waveform filters compare incoming data against a model, either of the background noise (autoregressive filter), or of the expected signal (phase match filter, pseudo-correlation filter).

Frequency-Wavenumber (fk) Power Spectrum - The representation in the frequency-wavenumber domain of coherent signal power in the waveform data from an array for a specified time interval. Calculation of fk power spectrum requires three Fourier transforms to convert time-sampling to frequency (designated by f), and longitude and latitude sampling to x and y wavenumbers (designated by k). Typically, fk power spectra are represented as 2D plots (not 3D), by collapsing the frequency information to a single value for each x and y slowness, by averaging values across the range of frequencies.

Frequency-Wavenumber (fk) Processing - A signal processing technique that can be applied to a short interval of waveform data from an array to determine if a signal is present and estimate the signal's azimuth and slowness. Waveform data are first converted to a frequency-wavenumber power spectrum and then further processing is done in the fk domain.

Noise - Portions of a waveform not containing event information (i.e., without apparent signals).

Rotation - A coordinate system transform that rotates raw channel (see channel, raw) data from a three component station to align the data's axes parallel and perpendicular to a specific azimuth and slowness (i.e., ray path). Rotation produces derived channels corresponding to an arriving signal's radial and transverse ground motion. The purpose of rotation is to enhance the SNR of signals of interest.

Signal - A portion of a waveform containing information from an event.

Signal Enhancement - Signal processing techniques including filtering (see filter, waveform), beamforming, and three component waveform data rotation, used to enhance the signal content, and reduce the noise content of waveform data.

Slowness - A measure of the inverse apparent velocity of a wave moving across the surface of the Earth at a station. The inverse of slowness is the apparent velocity of such a wave. Slowness is often used in phase identification and is sometimes used for determining event location.

Three Component Station - A seismic station with separate instruments measuring ground motion in three perpendicular directions: up-down, north-south, and east-west. These directions are often referred to as Z, N, and E. Also referred to as a 3C station.

Virtual Event Hypothesis - A trial event hypothesis created for analyzing waveform and alphanumeric data in an attempt to discover evidence supporting the existence of an actual event.

Virtual Origin - See virtual event hypothesis.

Waveform - A generic term for either a raw waveform (see waveform, raw) or a derived waveform (see waveform, derived).

Waveform, Derived - Output from a derived channel (see channel, derived) during a particular time interval (e.g., a bandpass filtered version of a raw waveform [see waveform, raw]; a beam created by summing multiple raw waveforms from the elements of an array).

Waveform, Raw - Output from a raw channel (see channel, raw) during a particular time interval.

IDC Specific:
None.

NOTES

General:
1. Analysts only select a new target phase when invoking this use case from 'Refines Event'. Since the Analyst is already refining an event hypothesis, the beam or rotation's target location is already known. Beam sets and rotation sets are not automatically recomputed after event hypothesis relocation, so the Analyst must enter this use case to recreate beamed or rotated channels. When refining an existing event, origin beams and rotated channels should already be calculated for non-detecting stations. These will be beamed to the first arriving P phase. To

create beams for any other phases, the Analyst must also enter this use case to create beamed or rotated channels targeting any phase other than the first arriving signal detection.

2. This use case allows creating detection beams by directly specifying azimuth and slowness. Two potential cases of when this is used are Researchers studying beam sets and Standalone Subsystem users working on stations in the field.

3. Storage of the enhanced signals is part of the 'Refines Event' UC.

4. The System shall convert analog filter transfer functions to digital filter transfer functions as a convenience to the Analyst so that they can enter analog filters. The intent is for the System to do the conversion from analog to digital one time rather than repeatedly doing the conversion.

5. The Analyst can select to rotate to an event hypothesis based on an empirical correction, for example Slowness Azimuth Source Correction (SASC).

6. The System Maintainer configures default beam sets and default rotation target sets.

IDC Specific:
None.

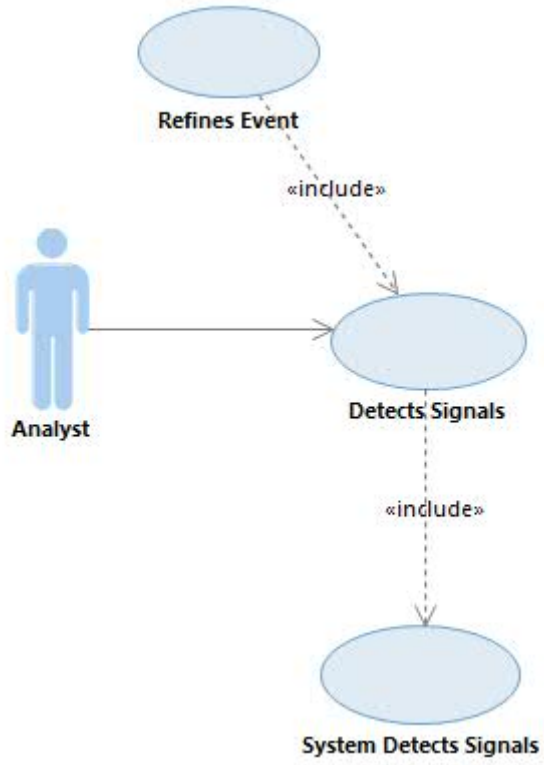
OPEN ISSUES

None.

IDC Use Case Report

UC-03.02.03 Detects Signals

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the Analyst detects new signals and modifies previously created signals in waveform data to refine an existing event. The Analyst detects signals on raw and derived channels or on detection feature maps. The Analyst views, updates, and rejects signal detections associated to an event. The Analyst associates unassociated signal detections to events. The Analyst assigns phase names to detections.

ACTOR DESCRIPTIONS

Analyst - The Analyst is a System User who analyzes events. This actor includes all the traditional analysis roles. Any Analyst can access all System event analysis capabilities from a use case perspective. Individual analyst capabilities may be further specified by operations procedures.

PRECONDITIONS

1. The System displays channel waveforms, signal detections, and event hypotheses associated with the Refines Event UC or Scans Waveforms and Unassociated Detections UC. The display indicates signal detections associated with the current event hypothesis (if selected), signal detections associated with any event hypothesis, and unassociated signal detections.

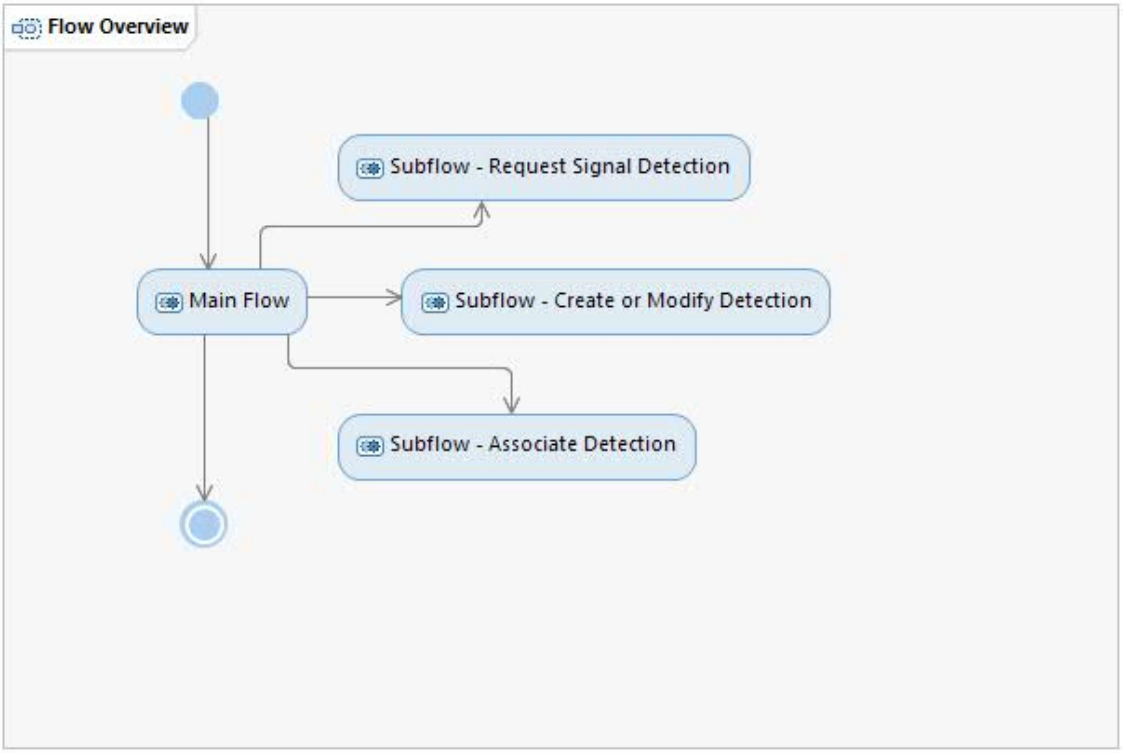
POSTCONDITIONS

1. Signal detections and the related signal detection parameters are created, modified, or marked as rejected.

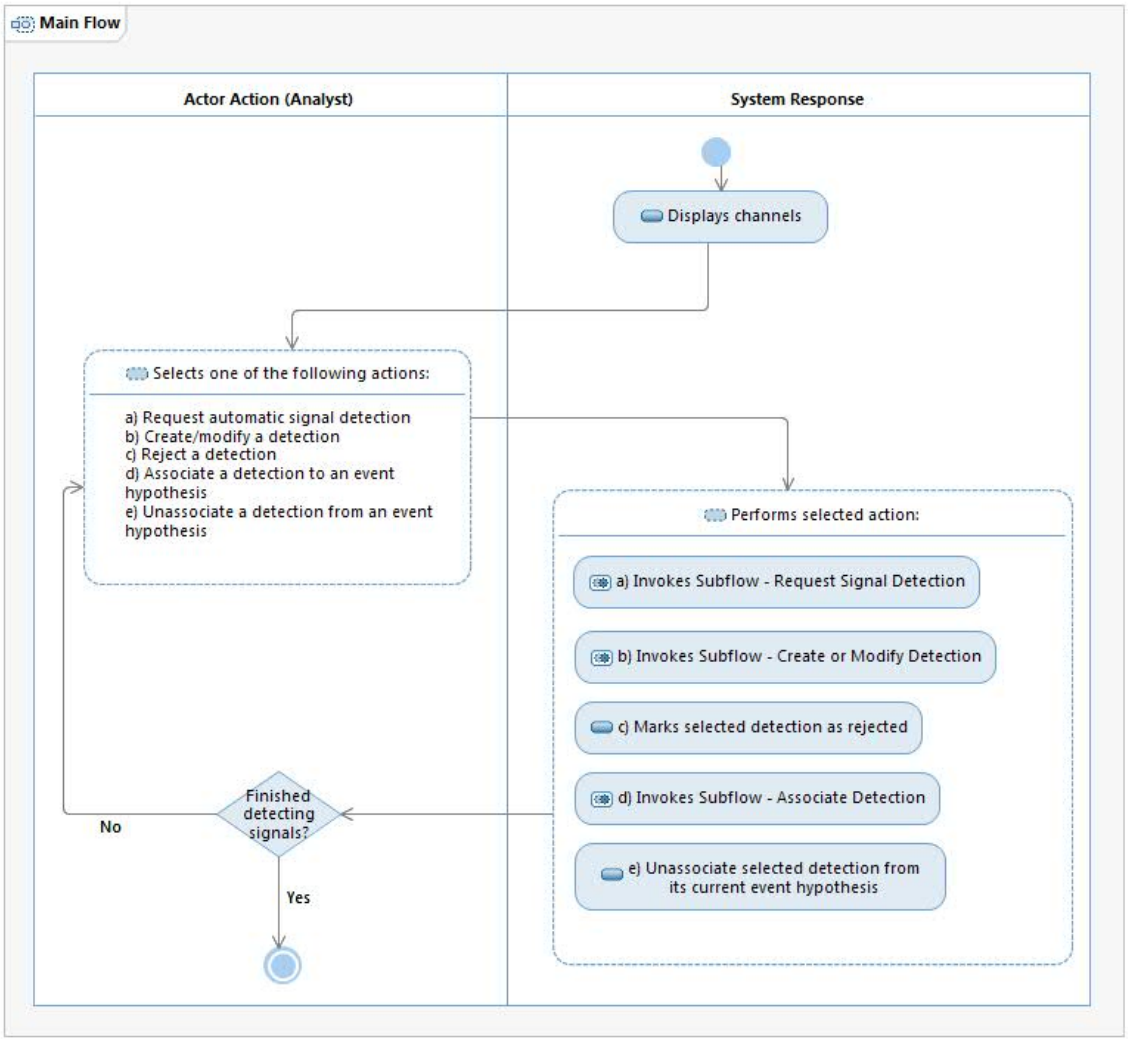
2. Signal detection associations with event hypotheses are updated.

ACTIVITY DIAGRAMS

Flow Overview



Main Flow



Action Descriptions

Action: "Displays channels"

The System displays channels for the selected time interval indicating associated and unassociated signal detections.

Action: "Selects one of the following actions:"

a) Request automatic signal detection:
- The analyst selects the time range for automatic signal detection.

b) Create/modify a detection:
- The analyst selects a channel and time to create a signal detection or selects an existing signal detection to modify.

c) Reject a detection:
- The analyst selects an existing signal detection to reject.

d) Associate a detection to an event hypothesis:

- The analyst selects an existing signal detection to associate and optionally selects an event hypothesis.

e) Unassociate a detection from an event hypothesis:
- The analyst selects an existing signal to unassociate.

Action: "c) Marks selected detection as rejected"
The System marks the signal detection as rejected but retains the signal detection for review or analysis. If the signal detection is associated to an event hypothesis the System also unassociates the signal detection from the event hypothesis.

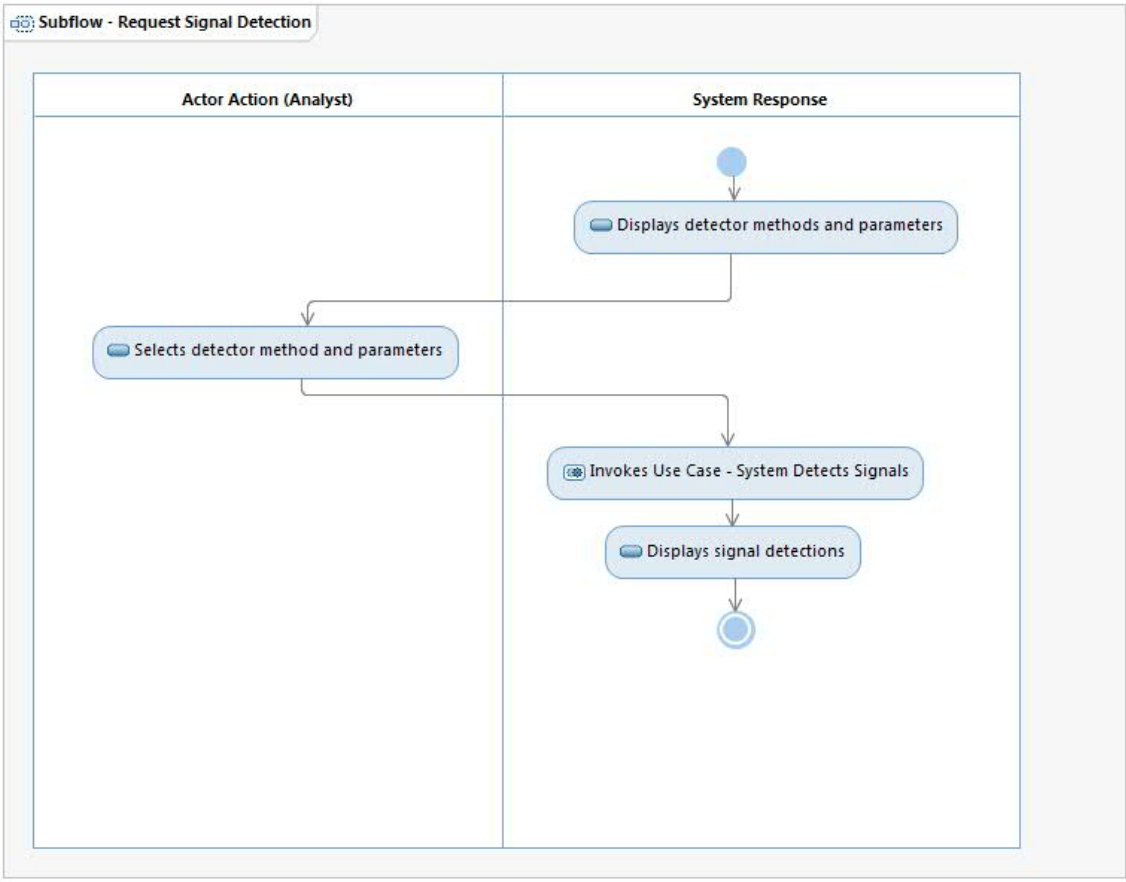
Action: "e) Unassociate selected detection from its current event hypothesis"
The System unassociates the signal detection from the event hypothesis and makes it available to be associated with other event hypotheses.

Alternate Flows
1. Action "Invokes Subflow - Create or Modify Detection" - This use case may begin at this step when included from 'Scans Waveforms and Unassociated Detections' UC.

2. Action "Invokes Subflow - Associate Detection" - This use case may begin at this step when included from 'Scans Waveforms and Unassociated Detections' UC.

3. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to 'Refines Event' UC.

Subflow - Request Signal Detection



Action Descriptions

Action: "Displays detector methods and parameters"

The System displays the methods for detecting signals (see 'System Detects Signals' UC) and the parameters associated with each method. The System uses threshold values for signal detectors configured by System Maintainer (see 'Configures Processing Components' UC). Examples of detection methods are power detector (STA/LTA) and Z detector.

Action: "Selects detector method and parameters"

The Analyst selects the System detection method and overrides any parameters associated with the method.

Action: "Invokes Use Case - System Detects Signals"

The System invokes the signal detection method selected by the Analyst using the selected parameters.

Action: "Displays signal detections"

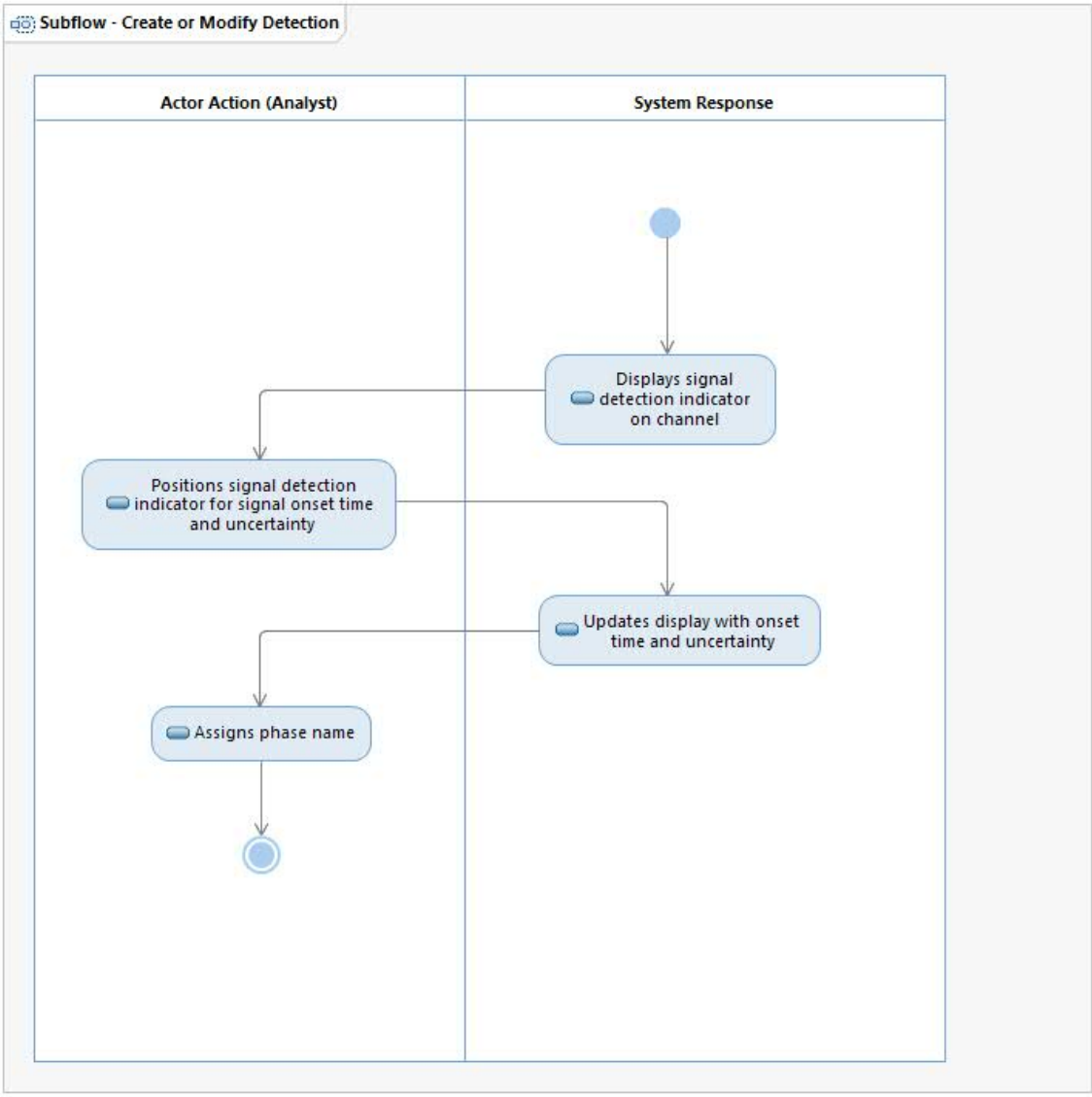
The System displays any new signal detections in addition to the existing detections.

Alternate Flows

1. Any Actor Action - The Analyst may choose to cancel, in which case this flow ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

Subflow - Create or Modify Detection



Action Descriptions

Action: "Displays signal detection indicator on channel"

The System highlights either the selected signal detection or desired signal detection time and channel.

Action: "Positions signal detection indicator for signal onset time and uncertainty"

The analyst may adjust the signal onset time and uncertainty for the selected signal detection.

Action: "Assigns phase name"

The Analyst selects or updates the appropriate phase for the signal.

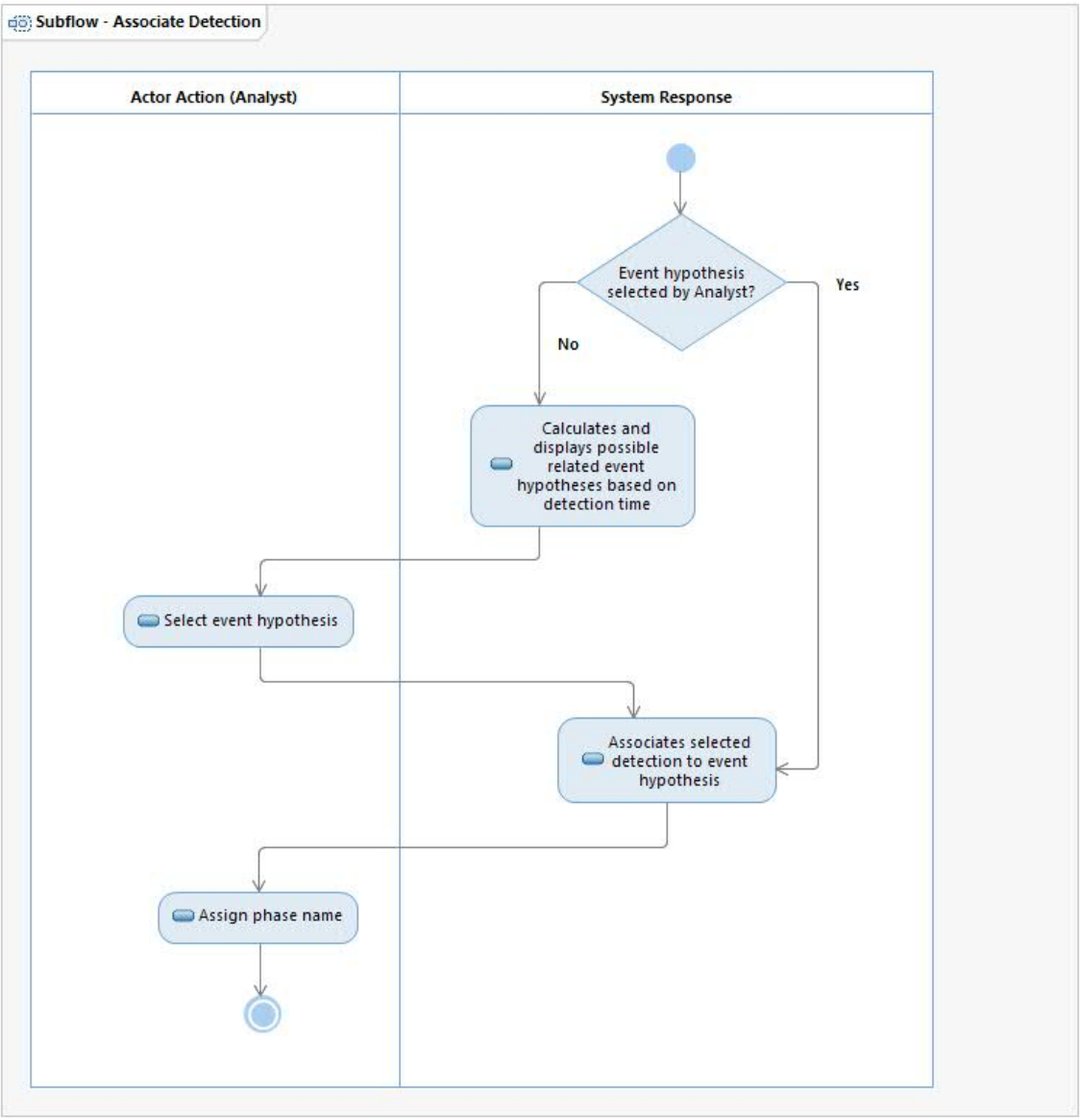
Alternate Flows

1. Any Actor Action - The Analyst may choose to cancel, in which case this flow ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

3. Any Actor Action - The Analyst has the capability to create signal detections when waveform data are not available.

Subflow - Associate Detection



Action Descriptions

Decision: "Event hypothesis selected by Analyst?"

Has the Analyst previously selected an event hypothesis to associate to the signal detection?

Action: "Calculates and displays possible related event hypotheses based on detection time"

The System lists a set of possible event hypotheses with the suggested phase for the selected signal detection based on time.

Action: "Select event hypothesis"
The Analyst selects a candidate event hypothesis for the selected signal detection.

Action: "Associates selected detection to event hypothesis"
The signal detection is associated with the selected event hypothesis.

Action: "Assign phase name"
The Analyst selects or updates the appropriate phase for the signal.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this flow ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

3. Action "Select event hypothesis" - If the selected event hypothesis is being actively reviewed by another Analyst, the System notifies the requesting Analyst. Any conflicts are resolved when the Event Hypotheses are saved, see 'Refines Event' UC.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1416: [*Threshold*] The System shall provide the Analyst the capability to add signal detections.

S-1417: [*Threshold*] The System shall provide the Analyst the capability to reject signal detections.

S-1418: [*Threshold*] The System shall provide the Analyst the capability to modify the time of signal detections on the waveform display.

S-1419: [*Threshold*] The System shall provide the Analyst the capability to create signal detections when waveform data is not available.

S-1529: [*Threshold*] The System shall provide the Analyst the capability to associate signal detections to existing event hypotheses.

S-1530: [*Threshold*] The System shall provide the Analyst the capability to unassociate signal detections from existing event hypotheses.

S-1531: [*Threshold*] The System shall provide the Analyst the capability to assign phase labels to signal detections.

S-1535: [*Threshold*] The System shall provide the Analyst the capability to invoke algorithms used during automated processing to find unassociated signal detections and associate them with existing event hypotheses.

S-1643: [*Threshold*] The System shall provide the Analyst the capability to map signal detections and their phase assignments from one channel to another channel.

S-1850: [*Extensibility*] The System shall provide the System User the capability to view temporal amplitude attenuation for infrasonic and hydroacoustic signals.

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-5621: [*Threshold*] The System shall by default invoke the same algorithms during interactive processing as those used in automated processing.

S-5851: [*Threshold*] The System shall provide the Analyst the capability to view Progressive Multi-Channel Correlation (PMCC) results.

S-5953: [*Threshold*] The System shall provide the Analyst the capability to view signal detections.

S-5954: [*Threshold*] The System shall provide the Analyst the capability to view signal detection phase designation on the waveform display.

S-6296: [*Threshold*] The System shall provide the Analyst the capability to view effective sound speed ratios at a selected altitude for a given meteorological model.

S-6297: [*Threshold*] The System shall provide the Analyst the capability to view infrasonic ray paths between a receiver and hypothesized source location when reviewing events with an infrasound phase.

S-6305: [*Threshold*] The System shall provide the Analyst the capability to select signal detection parameters.

IDC Specific:
S-5827: [*IDC only, Threshold*] The System shall provide the Analyst the capability to mark signal detections associated to an event so as to exclude them from event screening calculations.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Association - See signal association.

Channel - A generic term for either a raw channel (see channel, raw) or a derived channel (see channel, derived). A time interval of data from a channel is a waveform.

Channel, Derived - A source for time series data created by processing one or more raw channels (see channel, raw). Examples of common types of processing to form derived channels are filtering (see filter, waveform), beaming (see beamforming [beaming]), and rotation. Derived channels are generally created to enhance the SNR of signals.

Channel, Raw - A source for unprocessed time series data from a seismic, hydroacoustic, or infrasonic sensor (e.g., the output from a short period, vertical component seismometer).

Detection Feature Map - A matrix of values for a particular feature as measured at a particular station over time. The matrix contains a feature vector calculated for each point in time based on the processing of one or more waveforms from the station. The feature vector is a set of values indexed by secondary independent variables, for example, frequency. Detection feature maps are used to detect and identify signals. A spectrogram is an example of a detection feature map where the feature is signal amplitude and the index is frequency. Array coherence is another example where the feature is coherence (or another feature gated by a coherence threshold) and the index is frequency.

Signal Association - The process of linking (associating) a set of signal detections from a network of stations to an event hypothesis, either existing or new. Association is based on consistency of observed and predicted signal detection feature measurements (e.g., arrival time, azimuth, slowness). Signal association can be done automatically by the system (see pipeline processing), or manually by an analyst.

Signal Detection - A specific interval on a waveform marking the arrival of a signal of interest. Other portions of the waveform are noise.

IDC Specific:
None.

NOTES

General:
1. Retimed signals may cause other computed event attributes to need to be recalculated (see 'Refines Event' UC).

2. The Analyst references empirical knowledge from past events and geophysical models to guide in detecting signals.

3. The Detects Signals UIS defines how to map signal detections and their phase assignments from one channel to another channel (i.e., between channels of a 3-Component station or between array elements). (S-1643)

IDC Specific:
1. The Analyst can mark a signal detection associated to an event so as to exclude it from the event screening calculations.

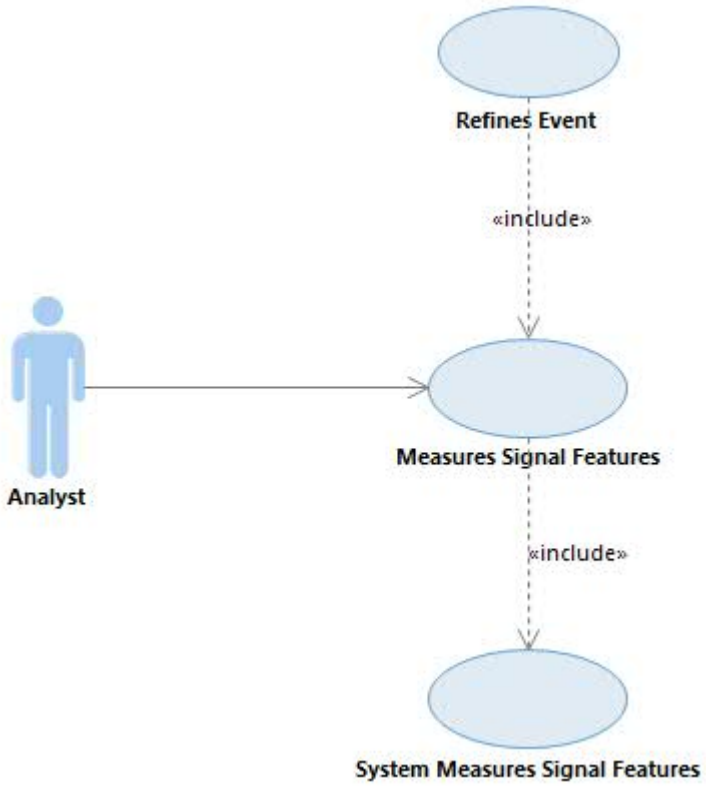
OPEN ISSUES

None.

IDC Use Case Report

UC-03.02.04 Measures Signal Features

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the Analyst measures signal features on waveform data. The Analyst measures the same signal features as are measured in pipeline processing (see 'System Measures Signal Features' UC), but the Analyst has the option to select the input parameters rather than the predefined parameters used during pipeline processing.

ACTOR DESCRIPTIONS

Analyst - The Analyst is a System User who analyzes events. This actor includes all the traditional analysis roles. Any Analyst can access all System event analysis capabilities from a use case perspective. Individual analyst capabilities may be further specified by operations procedures.

PRECONDITIONS

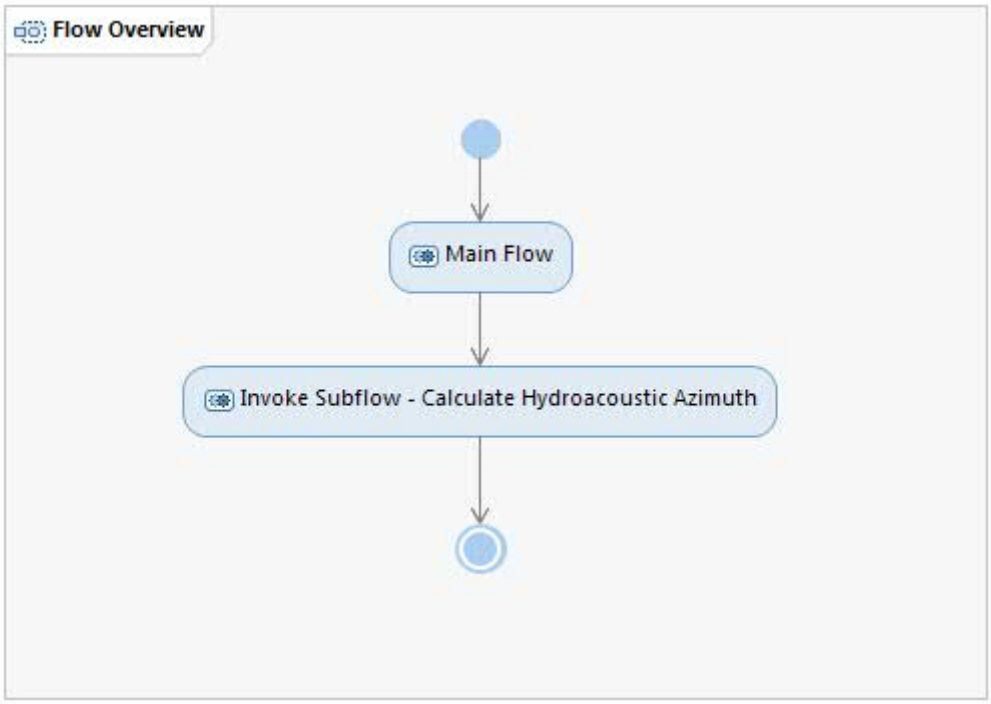
None.

POSTCONDITIONS

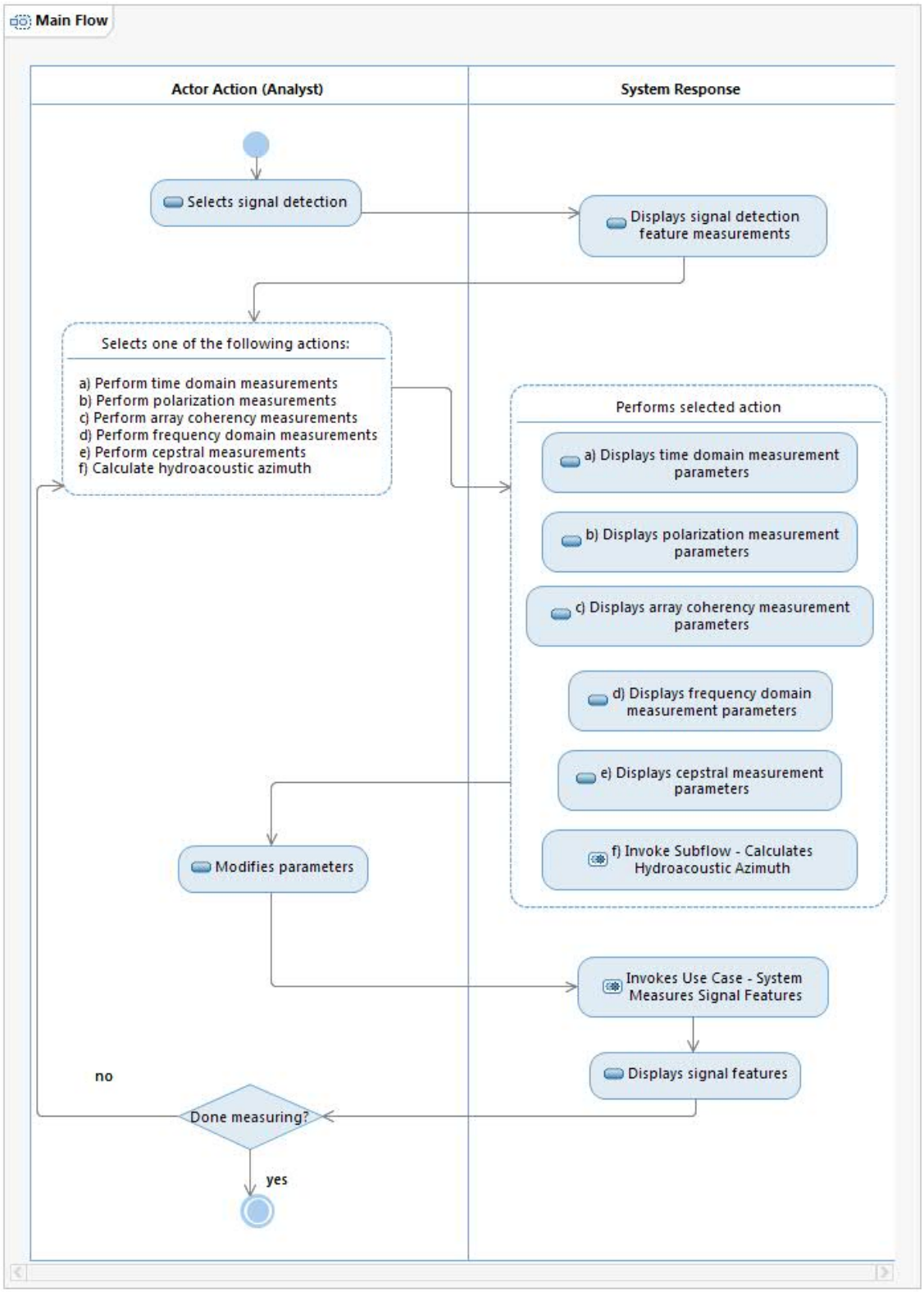
None.

ACTIVITY DIAGRAMS

Flow Overview



Main Flow



Action Descriptions

Action: "Selects signal detection"

The Analyst selects a signal detection to view its signal detection feature measurements.

Action: "Displays signal detection feature measurements"
The System displays time domain, polarization, array coherency, frequency domain, and cepstral signal detection feature measurements.

Action: "a) Displays time domain measurement parameters"
For hydroacoustic signal detections, the System displays the Hydroacoustic Arrival Group (HAG) and measurement parameters to compute onset time, termination time, probability-weighted time and uncertainty, signal summation time, total energy, intensity average time, peak energy and time, signal time spread, skewness, and kurtosis. For seismic or infrasonic signal detections, the System displays measurement parameters to compute onset time, amplitude and period.

If the selected signal detection is from a seismic station that is coda magnitude calibrated for the region containing an event hypothesis, the System displays parameters used to compute the moment rate spectra. These parameters are the calculation time window, the pre-signal detection noise window, defining behavior for each noise envelope, and whether the System should use theoretical or actual signal detections. These parameters have either default values previously configured by the System Maintainer (see 'Configures Processing Components' UC) or overridden values previously selected by the Analyst in this UC.

Action: "b) Displays polarization measurement parameters"
The System displays polarization parameters to compute the 3-component polarization features including 3-C amplitude, signal rectilinearity, planarity, long-axis incidence angle, short-axis incidence angle, horizontal-to-vertical power ratios, maximum-to-minimum ratio of the horizontal component, and azimuth. These parameters have either default values previously configured by the System Maintainer (see 'Configures Processing Components' UC) or overridden values previously selected by the Analyst in this UC.

Action: "c) Displays array coherency measurement parameters"
The System displays the array coherency parameters (e.g., contributing channels, whether the System should normalize the waveforms prior to computing the array coherency) to measure azimuth, azimuth uncertainty, slowness, slowness uncertainty, and array coherence for data originating from a seismic or infrasonic array station. These parameters have either default values previously configured by the System Maintainer (see 'Configures Processing Components' UC) or overridden values previously selected by the Analyst in this UC.

Action: "d) Displays frequency domain measurement parameters"
The System displays the frequency domain measurement parameters to measure total energy, total power, average power, power spectral density, and signal cepstrum of a seismic or infrasonic signal detection. These parameters have either default values previously configured by the System Maintainer (see 'Configures Processing Components' UC) or overridden values previously selected by the Analyst in this UC.

Action: "e) Displays cepstral measurement parameters"

For hydroacoustic signal detections, the System displays the cepstral measurement parameters in order to calculate the cepstrum and a set of parameters that characterize the signal. These parameters have either default values previously configured by the System Maintainer (see 'Configures Processing Components' UC) or overridden values previously selected by the Analyst in this UC.

Action: "Modifies parameters"
For some feature measurements, such as hydroacoustic time domain, cepstral, polarization, and array coherency measurements, the Analyst first selects an individual signal detection before selecting the measurement parameters to compute the new signal features. The Analyst may select, edit, and apply a measurement filter to emphasize signal to noise differences or apply a filter used in short period data. The Analyst may also adjust the time interval designating the first time the signal can be distinguished from noise and when the last energy arriving by direct path from a single source can no longer be discernable from background noise. The Analyst can also directly set signal detection feature measurement values and uncertainties (e.g., the Analyst may retime a signal detection or set the uncertainty on a signal detection onset time).

Action: "Invokes Use Case - System Measures Signal Features"
The System invokes the 'System Measures Signal Features' UC and provides the Analyst's selected signal detection, measurement time interval, signal detection feature measurement parameters, and selected measurement. The invoked use case measures features of the selected signal detection."

Action: "Displays signal features"
The System displays computed signal detection feature measurements.

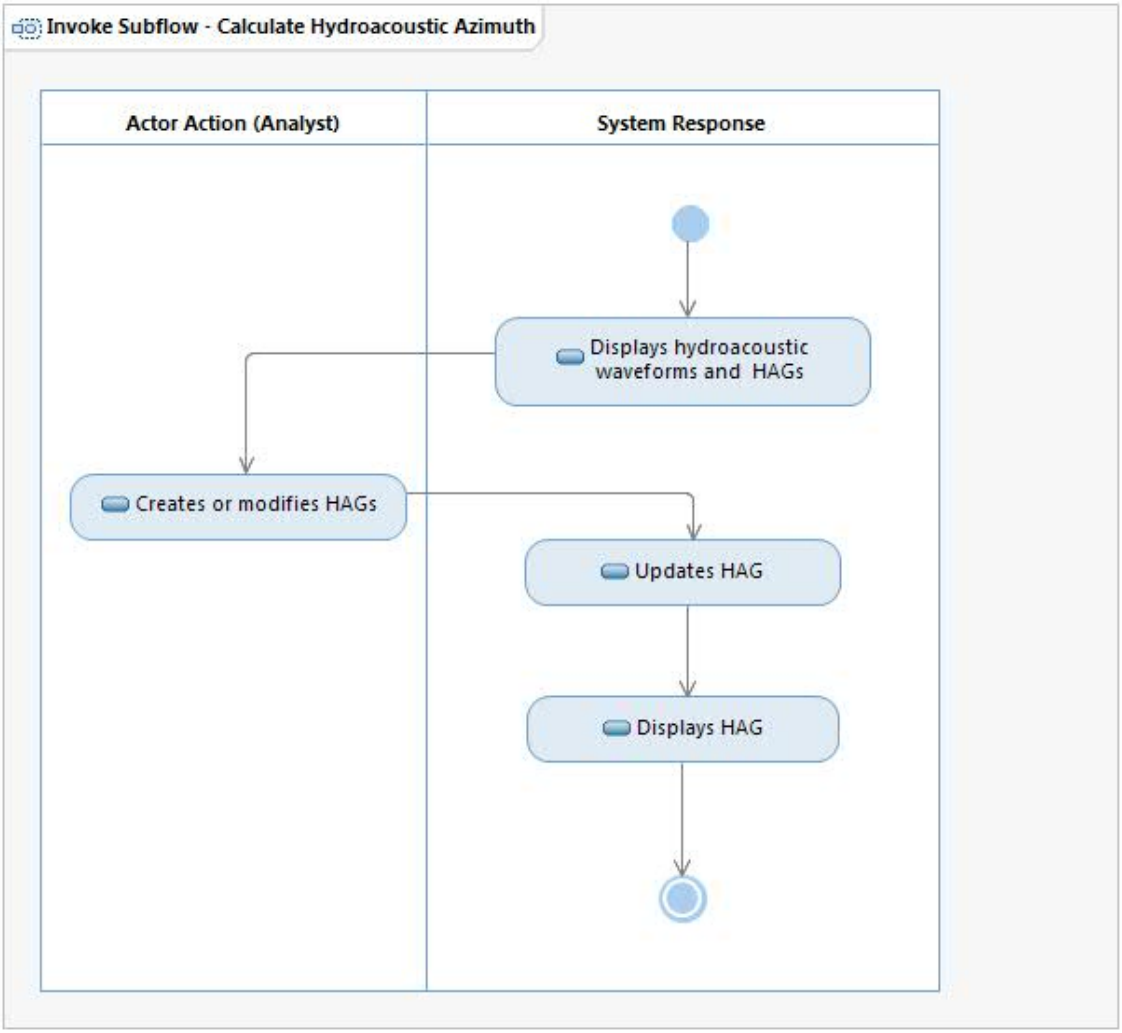
Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to 'Refines Event' UC.

2. Any Actor Action - The Analyst may undo/redo previous actions.

3. Action "Selects Signal Detection" - The Analyst may choose to skip this action when making coda measurements, in which case. the System displays coda measurement parameters for each calibrated seismic station during Action "Performs selected action: a) Displays time domain measurement parameters".

4. Action "Invokes Use Case - System Measures Signal Features" - The Analyst may choose to directly set signal detection feature measurement values rather than selecting parameters for use when invoking 'System Measures Signal Features' UC, in which case this action is skipped, and this flow continues.

Subflow - Calculate Hydroacoustic Azimuth



Action Descriptions

Action: "Displays hydroacoustic waveforms and HAGs"

The System displays the hydroacoustic waveforms related to the selected signal detection. For an H-phase station, waveforms and signal detections for all of the hydrophones in the HAG with the detection are shown. Separate feature measurements are made for each signal detection in the HAG.

Action: "Creates or modifies HAGs"

To create a HAG, the Analyst selects existing hydroacoustic signal detections that should be grouped into the HAG. The Analyst may choose to modify a HAG by selecting hydroacoustic signal detection(s) to remove from the HAG. The Analyst may choose to modify a HAG by selecting an existing HAG and the hydroacoustic signal detections to add to the HAG. The Analyst may choose to reject an existing HAG.

Action: "Updates HAG"

The System creates, modifies, or rejects the HAG based on the Analyst selections. The System rejects a HAG by designating it as rejected to remove it from further processing. The System preserves the rejected HAG's history, including the signal detections grouped by the HAG. The System makes the signal detections available for grouping into other HAGs.

Action: "Displays HAG"
The System updates the display to show the newly created or modified HAG and the signal detections it groups. If the Analyst selected to reject a HAG the System updates the display to remove the HAG and indicates that the signal detections previously contained in the rejected HAG are no longer contained in a HAG.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this subflow ends, and returns to the main flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1383: [*Threshold*] The System shall provide the Analyst the capability to view array coherence.

S-1426: [*Extensibility*] The System software shall provide an extensible architecture for integrating new amplitude algorithms and measurements.

S-1432: [*Threshold*] The System shall provide the Analyst the capability to view time domain measurements.

S-1433: [*Threshold*] The System shall provide the Analyst the capability to perform time domain waveform measurements.

S-1434: [*Threshold*] The System shall provide the Analyst the capability to select time domain waveform measurement parameters.

S-1435: [*Threshold*] The System shall provide the Analyst the capability to modify time domain waveform measurements.

S-1445: [*Threshold*] The System shall provide the Analyst the capability to view polarization feature measurements.

S-1446: [*Threshold*] The System shall provide the Analyst the capability to make polarization feature measurements.

S-1447: [*Threshold*] The System shall provide the Analyst the capability to select polarization feature measurement parameters per channel.

S-1460: [*Threshold*] The System shall provide the Analyst the capability to make frequency domain waveform measurements.

S-1461: [*Threshold*] The System shall provide the Analyst the capability to view frequency domain waveform measurements.

S-1462: [*Threshold*] The System shall provide the Analyst the capability to select frequency domain waveform measurement parameters.

S-1478: [*Threshold*] The System shall provide the Analyst the capability to view normalized fk spectra plots for a selected set of waveforms.

S-1479: [*Threshold*] The System shall provide the Analyst the capability to view absolute fk spectra plots for a selected set of waveforms.

S-1480: [*Threshold*] The System shall provide the Analyst the capability to apply fk space based filters.

S-1481: [*Threshold*] The System shall provide the Analyst the capability to make fk spectra measurements on fk spectra.

S-1482: [*Threshold*] The System shall provide the Analyst the capability to select fk spectra measurement parameters.

S-1483: [*Threshold*] The System shall provide the Analyst the capability to normalize waveform data for an array prior to fk spectra calculations.

S-1606: [*Threshold*] The System shall provide the Analyst the capability to set uncertainties for observed signal detection measurements.

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2102: [*Threshold*] The System shall provide the System User the capability to view power spectral density for any channel.

S-2103: [*Threshold*] The System shall provide the System User the capability to select the parameters used to calculate power spectral density for any channel.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-2414: [*Threshold*] The System shall provide the Analyst the capability to select values for the hydroacoustic signal detection grouping criteria.

S-2415: [*Threshold*] The System shall provide the Analyst the capability to create hydroacoustic signal detection groups.

S-2416: [*Threshold*] The System shall provide the Analyst the capability to modify hydroacoustic signal detection groups.

S-5621: [*Threshold*] The System shall by default invoke the same algorithms during interactive processing as those used in automated processing.

S-5637: [*Threshold*] The System shall provide the Analyst the capability to create infrasonic signal detection groups.

S-5638: [*Threshold*] The System shall provide the Analyst the capability to modify infrasonic signal detection groups.

S-5851: [*Threshold*] The System shall provide the Analyst the capability to view Progressive Multi-Channel Correlation (PMCC) results.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Cepstral Domain Measurements - Measurements made in the cepstral domain for characterizing a signal of interest, in particular, hydroacoustic signals. The cepstral domain highlights periodicities in the spectrum (frequency domain). A cepstrum of a waveform is the Fourier transform of the waveform's power spectrum. The independent variable of the cepstrum is called quefrency, expressed in units of time, but representing the period of harmonic features of the waveform.

Frequency Domain Measurements - Measurements made in the frequency domain for characterizing a signal of interest, including: total energy, total power, average power, power spectral density, and signal cepstrum. A segment of waveform data (a time-series) is transformed to the frequency domain using a Fourier transform.

Frequency-Wavenumber (fk) Measurements - Measurements made from the fk transformed data (see frequency-wavenumber [fk] processing) of an array: azimuth, azimuth uncertainty, slowness, slowness uncertainty, and array coherence.

Frequency-Wavenumber (fk) Power Spectrum - The representation in the frequency-wavenumber domain of coherent signal power in the waveform data from an array for a specified time interval. Calculation of fk power spectrum requires three Fourier transforms to convert time-sampling to frequency (designated by f), and longitude and latitude sampling to x and y wavenumbers (designated by k). Typically, fk power spectra are represented as 2D plots (not 3D), by collapsing the frequency information to a single value for each x and y slowness, by averaging values across the range of frequencies.

Frequency-Wavenumber (fk) Processing - A signal processing technique that can be applied to a short interval of waveform data from an array to determine if a signal is present and estimate the signal's azimuth and slowness. Waveform data are first converted to a frequency-wavenumber power spectrum and then further processing is done in the fk domain.

Hydroacoustic Arrival Group (HAG) - A group of signal detections on different hydrophones from a single hydroacoustic station that have been determined to come from the same event and that can be used to determine azimuth back to the event. HAGs can only be formed for multiple element (array) stations, and hence apply to H stations, but not T stations.

Hydroacoustic Time Domain Measurements - Measurements made directly on waveforms from hydroacoustic sensors, including: signal termination time, signal summation time, signal time spread, signal skewness, signal kurtosis, peak energy in a defined time period, intensity average time in a defined time period, peak energy in a defined time period, and crossing counts (the number of times a waveform crosses a threshold in a defined time period).

Phase - An indication of the path and type of a signal originating from an event traveling through the body of the Earth, the oceans, or the atmosphere. For example, the seismic P phase refers to a compressional wave refracting within the mantle of the Earth, while the seismic ScS phase refers to a shear wave reflecting off the outer core boundary.

Polarization Features - Features derived from the analysis of three component data (see three component station) that characterize how a signal has been partitioned across the components. Polarization features can be used to identify phase type and for association with an event hypothesis. Polarization features include: azimuth, azimuth uncertainty, slowness, slowness uncertainty, rectilinearity, planarity, horizontal-to-vertical power ratio, and short and long axis incidence angles.

Signal Characterization - The process of measuring signal detection features for the purpose of determining the phase of a signal detection, and for determining whether or not a signal detection is consistent with an event hypothesis (see signal association).

Signal Detection Feature - A feature associated with a signal detection (e.g., arrival time, back azimuth, horizontal slowness, amplitude, frequency content).

Signal Detection Feature Measurement - A measurement of a signal detection feature, including measurement uncertainty.

Three Component Station - A seismic station with separate instruments measuring ground motion in three perpendicular directions: up-down, north-south, and east-west. These directions are often referred to as Z, N, and E. Also referred to as a 3C station.

Time Domain Measurements - Measurements made directly on time-series data (i.e., waveforms). Examples of general time domain measurements include onset time, amplitude, and period.

IDC Specific:
None.

NOTES

General:
1. The Analyst references empirical knowledge from past events and geophysical models to guide in measuring signal features.

2. Array coherency measurements include coherent signal power (frequency-wavenumber (fk) spectra) and progressive multiple channel coherence (PMCC).

IDC Specific:
None.

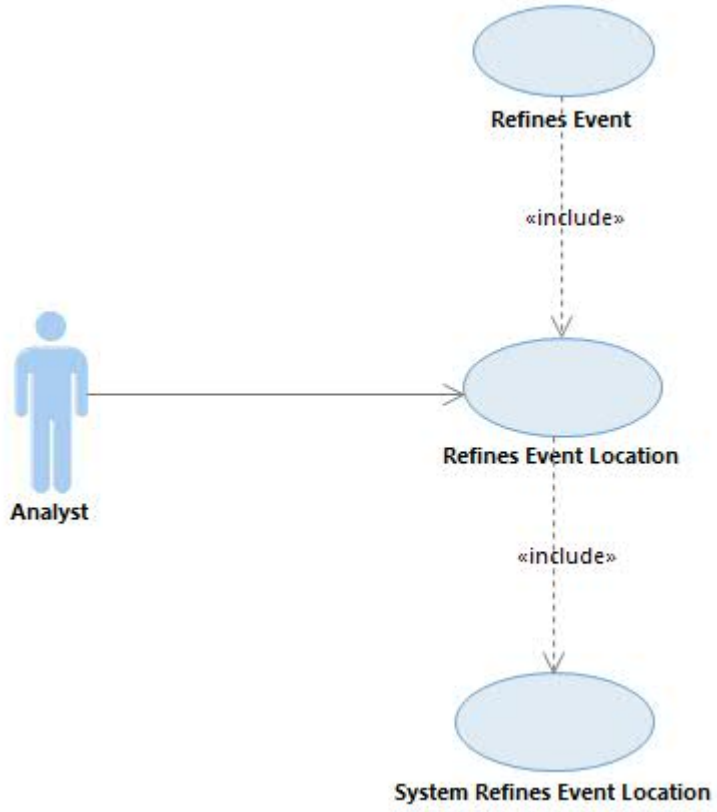
OPEN ISSUES

None.

IDC Use Case Report

UC-03.02.05 Refines Event Location

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the Analyst refines event hypothesis location solutions. The Analyst generates event hypotheses using the same algorithms as pipeline processing (see 'System Refines Event Location' UC), but the Analyst has the option to select the input parameters rather than using the predefined parameters used during pipeline processing. The System indicates which measurements are invalidated by the relocation (e.g., beams, magnitudes).

ACTOR DESCRIPTIONS

Analyst - The Analyst is a System User who analyzes events. This actor includes all the traditional analysis roles. Any Analyst can access all System event analysis capabilities from a use case perspective. Individual analyst capabilities may be further specified by operations procedures.

PRECONDITIONS

1. An event hypothesis has been selected for relocation.

POSTCONDITIONS

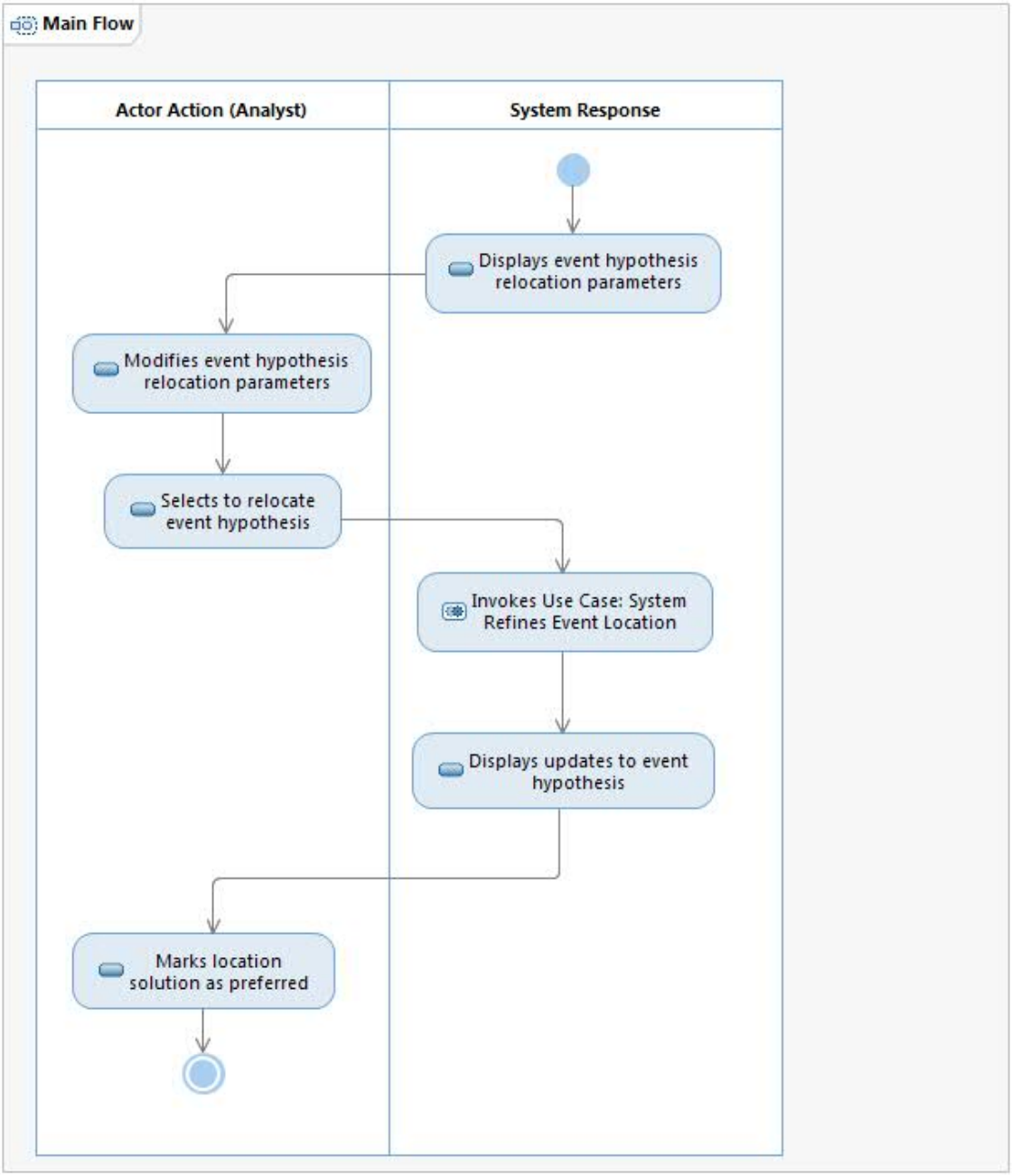
1. The event hypothesis location is updated.

2. The defining/non-defining state has been updated for the event hypothesis locations' signal detection feature measurements.

3. The System marks processing results that were made inconsistent (e.g., beams, Analyst-calculated magnitudes) during event hypothesis relocation.

ACTIVITY DIAGRAMS

Main Flow



Action Descriptions

Action: "Displays event hypothesis relocation parameters"

The System displays the event hypothesis relocation parameters described in the 'System Refines Event Location' UC.

Action: "Modifies event hypothesis relocation parameters"

The Analyst may override the event hypothesis relocation parameters described in the 'System Refines Event Location' UC. Some of these parameters include:

- Whether to compute unrestrained and/or restrained (by lat/lon, depth, and/or time) location solution(s)
- The confidence level use to compute an event hypothesis location bound.
- The type of uncertainty bound to compute (coverage, confidence, and/or k-weighted bound with associated weight). The Analyst cannot prevent the System from computing a coverage bound.
- Location defining / non-defining behavior for travel time, azimuth, and/or slowness signal detection feature measurements
- Location defining / non-defining behavior by channel and/or phase
- The models to use for calculating travel time, azimuth, and slowness signal detection feature measurements (including correction surfaces and master event corrections)
- The location algorithm to use

Action: "Invokes Use Case: System Refines Event Location"
The System invokes the 'System Refines Event Location' UC to refine the event hypothesis location using Analyst-specified input parameters and algorithm. The System can change a location defining setting made by the Analyst to be non-defining in order to make the location solution converge.

Action: "Displays updates to event hypothesis"
The System displays updated event hypothesis location and magnitude information and indicates which location and magnitude solution are preferred.

Action: "Marks location solution as preferred"
The Analyst indicates which location solution within the event hypothesis location solution set is preferred for this event location.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to 'Refines Event' UC.

2. Any Actor Action - The Analyst may undo/redo previous actions.

3. Action “Displays event hypothesis relocation parameters” - When this use case is invoked to perform master event relocation the System displays both the current and master event hypothesis, their related waveforms, associated signal detections (including feature measurements), and computes signal detection onset time differences between the matching signal detections.

4. Action "Modifies event hypothesis relocation parameters" - When this use case is invoked to perform master event relocation the Analyst finds matching signal detections between the current and master event hypotheses. This is done by aligning waveforms, retiming signal detections associated to the current event hypothesis and/or mapping signal detections from the master event hypothesis to the current event hypothesis. Only travel time signal detection feature measurements from the current event hypothesis that have corresponding signal detections in the master event hypothesis can be set as defining.

5. Action "Selects to relocate event hypothesis" - When the use case is invoked to perform master event relocation the Analyst selects to relocate the current event hypothesis relative to the master event hypothesis.

6. Action "Invoke Use Case - System Refines Event Location" - The event hypothesis relocation calculation may not be able to refine the event location (e.g. the location solution does not converge, incorrect inputs were specified), in which case the Analyst is informed, and this use case ends.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1607: [*Threshold*] The System shall provide the Analyst the capability to select the confidence level used to compute an event hypothesis location uncertainty bound.

S-1608: [*Threshold*] The System shall provide the Analyst the capability to select the type of each event hypothesis location uncertainty bound to compute.

S-1610: [*Threshold*] The System shall provide the Analyst the capability to select the defining/non-defining state for a signal detection time measurement for event hypothesis relocation unless prohibited by the default defining/non-defining state.

S-1611: [*Threshold*] The System shall provide the Analyst the capability to select the defining/non-defining state for a signal detection azimuth measurement for event hypothesis relocation unless prohibited by the default defining/non-defining state.

S-1612: [*Threshold*] The System shall provide the Analyst the capability to select the defining/non-defining state for a signal detection slowness measurement for event hypothesis relocation unless prohibited by the default defining/non-defining state.

S-1613: [*Threshold*] The System shall provide the Analyst the capability to select the defining/non-defining state for signal detection measurements for event hypothesis relocation based on channel unless prohibited by the default defining/non-defining state.

S-1614: [*Threshold*] The System shall provide the Analyst the capability to select the defining/non-defining state for signal detection measurements for event hypothesis relocation based on signal detection phase assignment unless prohibited by the default defining/non-defining state.

S-1615: [*Threshold*] The System shall provide the Analyst the capability to relocate event hypotheses.

S-1615: [*Threshold*] The System shall provide the Analyst the capability to relocate event hypotheses.

S-1636: [*Threshold*] The System shall provide the Analyst the capability to compute restrained event hypothesis locations.

S-1637: [*Threshold*] The System shall provide the Analyst the capability to compute unrestrained event hypothesis locations.

S-1811: [*Threshold*] The System shall provide the Analyst the capability to select the earth model used for an earth model prediction.

S-1812: [*Threshold*] The System shall provide the Analyst the capability to select the correction surface used for correcting an earth model prediction.

S-1813: [*Threshold*] The System shall provide the Analyst the capability to apply Master Event Corrections.

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-5621: [*Threshold*] The System shall by default invoke the same algorithms during interactive processing as those used in automated processing.

S-5852: [*Extensibility*] The System shall provide the Analyst the capability to view the model parameters used to predict signal propagation.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Defining/Non-Defining - Any observation that contributes to the determination of an event attribute is considered to be "defining" for that attribute. The detection of an event, the location of an event (see event location), the magnitude of an event (see event magnitude, network), and the source type assigned to an event are all determined by specific types of defining observations (travel time, azimuth, slowness, amplitude) from one or more phases recorded by one or more stations. If an observation is linked to an event (associated), but does not contribute to the calculation of an event attribute, then it is considered to be non-defining for that attribute.

Event - The estimate by the System or Analyst of the occurrence of some transient source of energy within the Earth's body, oceans, or atmosphere that can be detected by seismic, hydroacoustic, and/or infrasonic sensors. For the same event, many different event hypotheses may be created at different processing stages. One of these event hypotheses must be designated as preferred.

Event Epicenter - An event's 2D geographic location as described by latitude and longitude (i.e., the position on a map). This is in contrast to an event hypocenter, which refers to latitude, longitude, and depth.

Event Hypocenter - An event's 3D spatial location as described by latitude, longitude, and depth. This is in contrast to an event epicenter, which refers only to the latitude and longitude (i.e., the position on a map).

Event Hypothesis - A proposed solution for an Event. Each event consists of a sequence of event hypotheses that describe an evolution to a final best model of the event. Each event hypothesis is composed of a set of associated signal detections and has one or more event hypothesis location solutions, one of which must be designated as preferred.

Event Hypothesis Location Solution - An estimate of an event location (latitude, longitude, depth, origin time) that is tied to a particular event hypothesis. Each location solution is based on a set of defining signal detection feature measurements (e.g., time, azimuth, slowness).

Event Location - The combination of an event's spatial location (see event hypocenter), temporal location, spatial location uncertainty, and temporal location uncertainty.

Master Event Relocation - A method of relative event relocation where the new location is determined relative to an event with a known, fixed location (the master event). The location of the new event is determined by minimizing the travel time differences between the signal detections of the new event and the master event. Assuming the two events are in fact close to each other, this relative location can be determined with significantly greater precision than a standard relocation. However, the location accuracy depends completely on the location accuracy of the master event.

Origin - See event hypothesis location solution.

IDC Specific:
None.

NOTES

General:
1. When an event hypothesis is relocated not all the related information is automatically updated. Any information that is not updated is marked as inconsistent. It is left to the Analyst to decide when a change to an event hypothesis location is significant enough to warrant re-computing the inconsistent derived channels, signal detections, signal detection feature measurements, or other values. The System automatically recalculates inconsistent values (beams, magnitudes, etc.)

when an event hypothesis location moves more than a pre-configured distance in time/space; the System Maintainer configures this threshold. Post-Analyst processing will correct any inconsistent values the Analyst did not correct during their Analysis session

2. The event hypothesis magnitude estimates automatically computed after event hypothesis relocation are computed using the updated event hypothesis location and, potentially, signal detection amplitudes on derived channels beamed or rotated to the original event hypothesis location. This inconsistency is a direct consequence of the previous note. The recalculation of magnitude estimates after event hypothesis relocation is defined by the System Maintainer in 'Defines Processing Sequence' UC. Magnitude estimates are recomputed in 'System Refines Event Magnitude' UC.

3. In this use case, relative event relocation is limited to master event relocation (relocating the current event hypothesis relative to a single master event hypothesis). Multiple event relocation is covered in the 'Performs Multiple Event Relocation' UC.

4. The 'Refines Event' UC is where the Analyst indicates which event hypothesis is the Analyst's preferred event hypothesis. This is also where location information may be stored by the Analyst.

IDC Specific:
None.

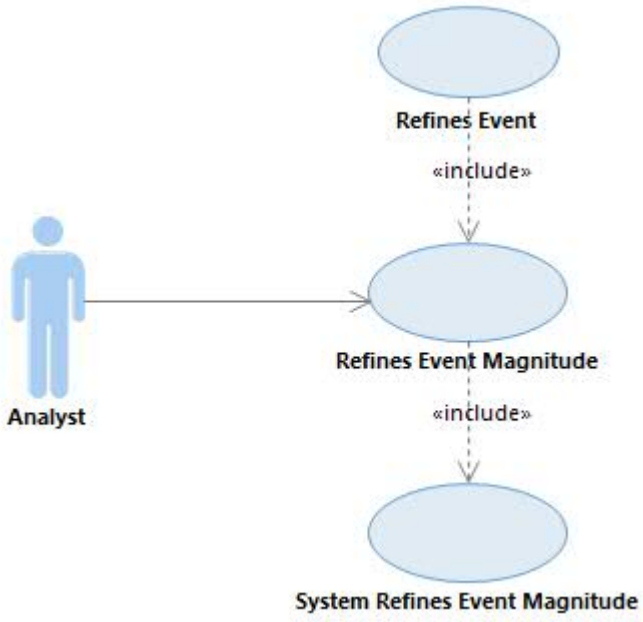
OPEN ISSUES

None.

IDC Use Case Report

UC-03.02.06 Refines Event Magnitude

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the Analyst refines estimated event magnitudes for an existing event hypothesis. The Analyst invokes the same magnitude algorithms used in pipeline processing (see 'System Refines Event Magnitude' UC) or additional magnitude estimation algorithms. The Analyst configures input parameters for estimating magnitude.

ACTOR DESCRIPTIONS

Analyst - The Analyst is a System User who analyzes events. This actor includes all the traditional analysis roles. Any Analyst can access all System event analysis capabilities from a use case perspective. Individual analyst capabilities may be further specified by operations procedures.

PRECONDITIONS

1. An event hypothesis (including location solution) is available for magnitude estimation.

2. Any signal detection features (e.g., amplitude, period) required to estimate the magnitude have been measured (see 'Measures Signal Features' UC).

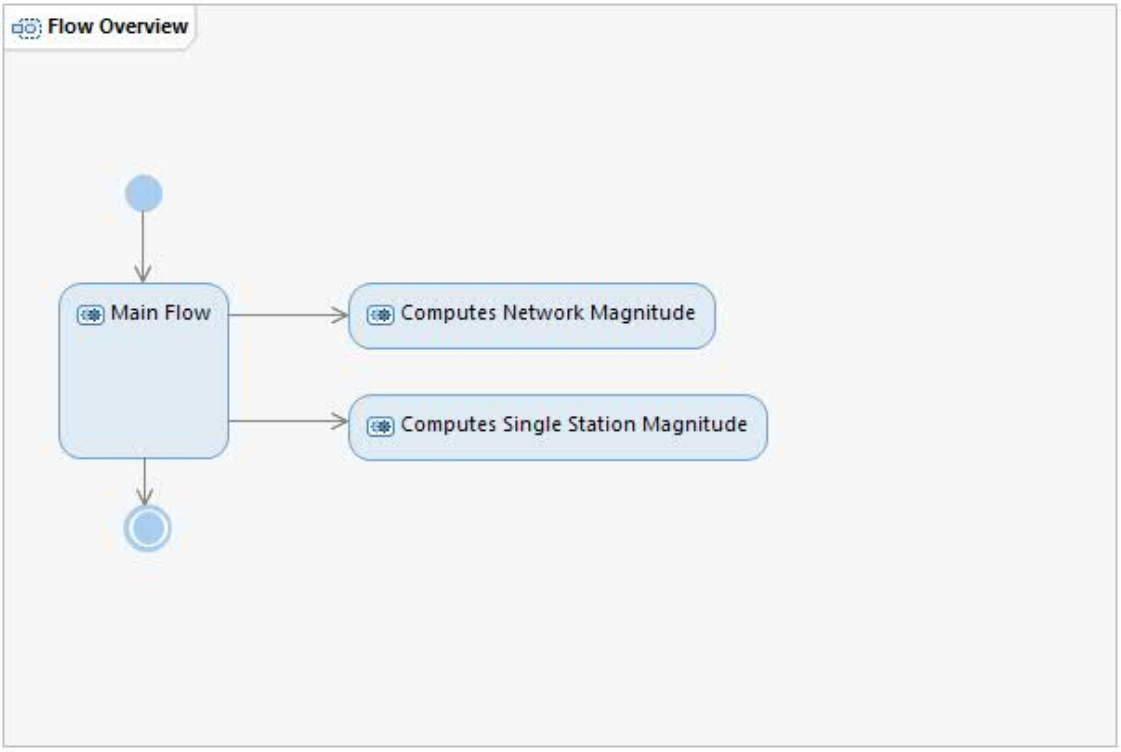
POSTCONDITIONS

1. The event hypothesis magnitude is updated.

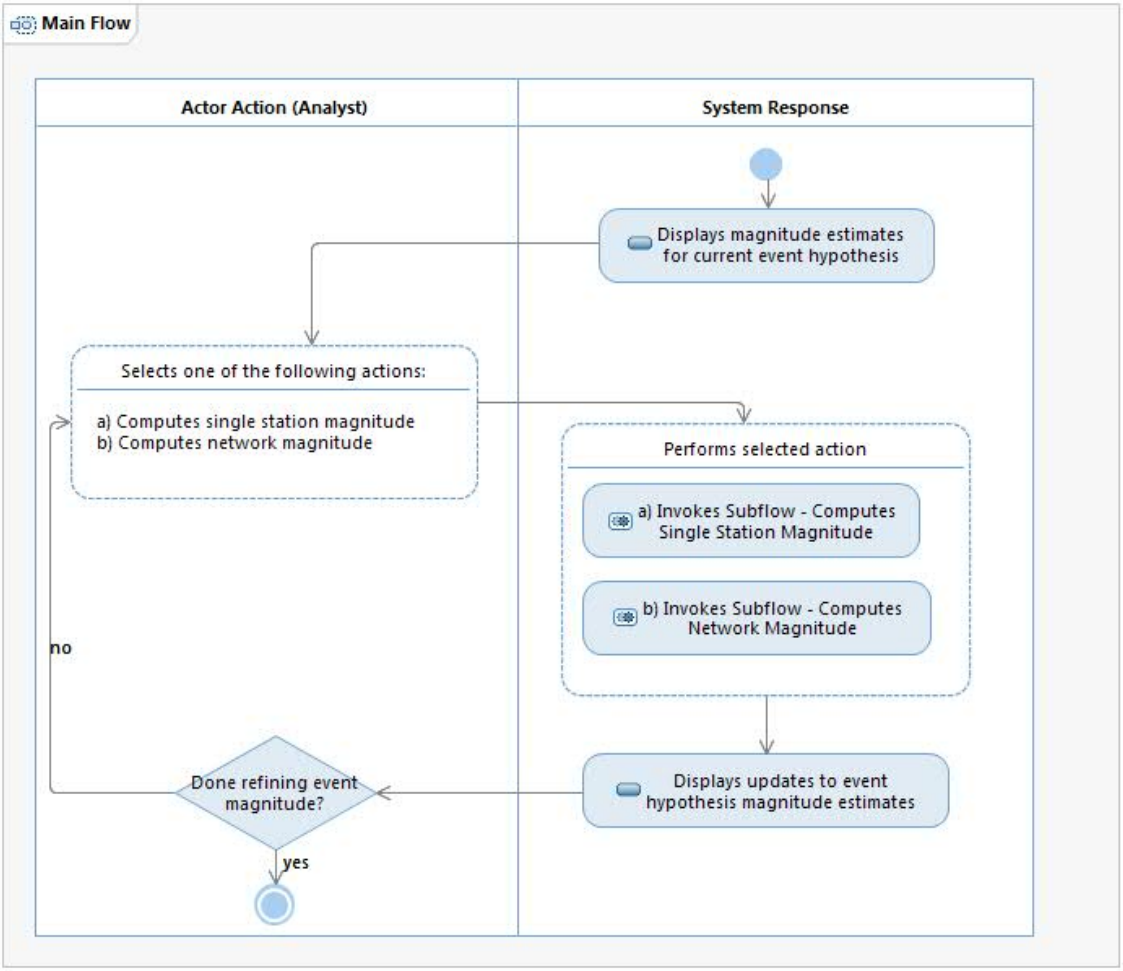
2. The defining/non-defining state has been updated for the event hypothesis magnitude's signal detection feature measurements.

ACTIVITY DIAGRAMS

Flow Overview



Main Flow



Action Descriptions

Action: "Displays magnitude estimates for current event hypothesis"

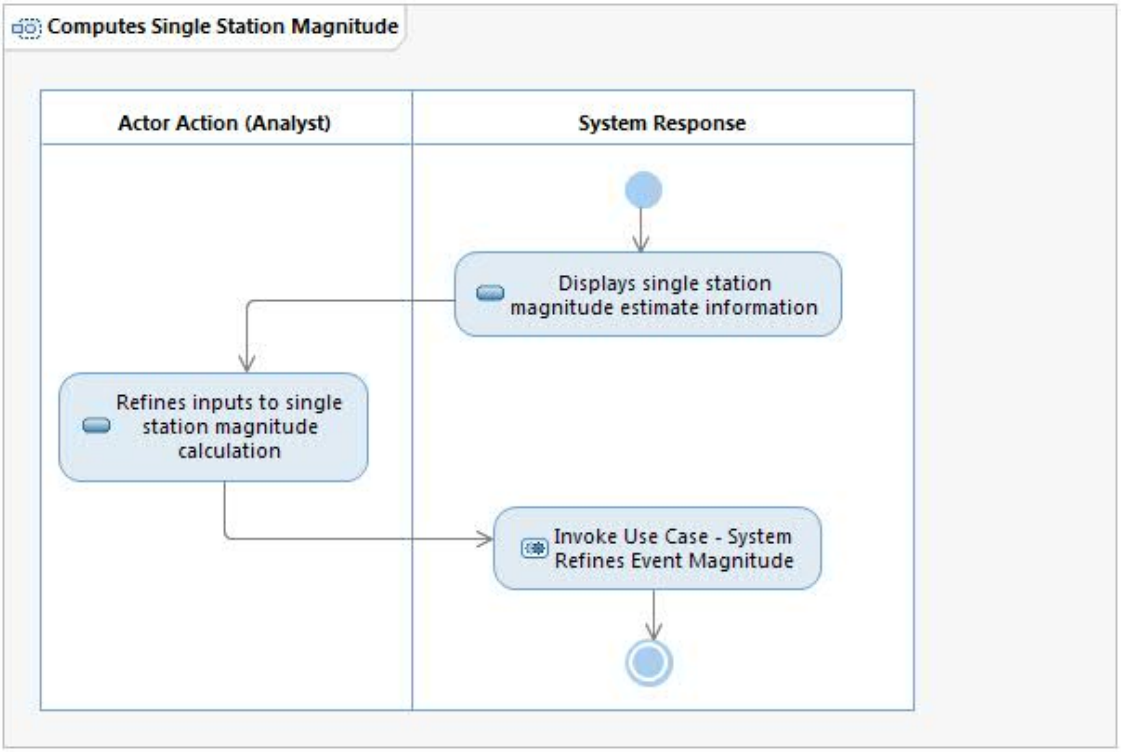
The System displays the magnitude estimates that have been calculated for the current event hypothesis.

Alternate Flows

1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to 'Refines Event' UC.

2. Any Actor Action - The Analyst may undo/redo previous actions.

Computes Single Station Magnitude



Action Descriptions

Action: "Displays single station magnitude estimate information"

The System displays the single station magnitude estimates that have been calculated for the current event hypothesis.

Magnitude estimate information includes:
- Single station magnitudes
- Residual information (if network magnitude is available)
- Distance of station from event
- Signal detection measurements (e.g., amplitude)

Action: "Refines inputs to single station magnitude calculation"

The Analyst selects the inputs to the magnitude calculation which includes:
- magnitude estimate type (e.g., ML, mb, or MS)
- signal detection measurements
- attenuation earth model
- waveform data (for coda measurements)
- selected event hypothesis (for relative magnitude calculations)

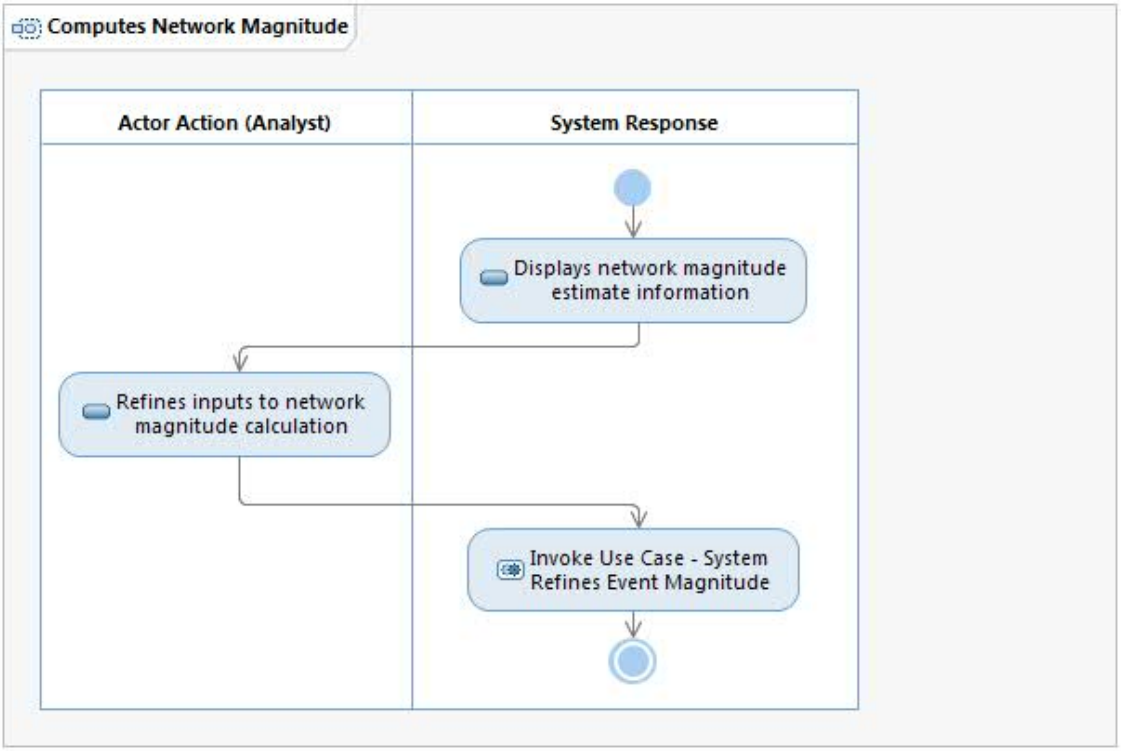
The System Maintainer configures default values for which stations and signal detections are magnitude defining, the Earth or empirical models used to estimate loss in signal amplitude, and the signal enhancement (e.g., waveform filter) and waveform envelope parameters used by Mwcoda estimation (see 'Configures Processing Components' UC).

Action: "Invoke Use Case - System Refines Event Magnitude"
The System invokes the 'System Refines Event Magnitude' UC to refine the event hypothesis magnitude using Analyst-specified input parameters.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this subflow ends, and returns to the Main Flow.

2. Action "Invoke Use Case - System Refines Event Magnitude"- The event hypothesis magnitude estimate calculation may not be able to refine the event magnitude, in which case the Analyst is informed, and this subflow ends, and returns to the Main Flow.

Computes Network Magnitude



Action Descriptions
Action: "Displays network magnitude estimate information"
The System displays the network magnitude estimates that have been calculated for the current event hypothesis.

Magnitude estimate information includes:
- Network magnitude
- Individual station magnitudes
- A map of stations whose arrivals are included in the magnitude calculation
- Residual information
- Distance of stations from event
- Signal detection measurements (e.g., amplitude)

Action: "Refines inputs to network magnitude calculation"
The Analyst selects the inputs to the network magnitude calculation which includes:
- stations (including which are defining)
- magnitude estimate type (e.g., ML, mb, or MS)
- signal detections

The System Maintainer configures default values for which stations and signal detections are magnitude defining, the Earth or empirical models used to estimate loss in signal amplitude, and the signal enhancement (e.g., waveform filter) and waveform envelope parameters used by Mwcoda estimation (see 'Configures Processing Components' UC).

Action: "Invoke Use Case - System Refines Event Magnitude"
The System invokes the 'System Refines Event Magnitude' UC to refine the event hypothesis magnitude using Analyst-specified input parameters and algorithm. The System will not change magnitude defining / non-defining settings made by the Analyst.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this subflow ends, and returns to the Main Flow.

2. Action "Invoke Use Case - System Refines Event Magnitude"- The event hypothesis magnitude estimate calculation may not be able to refine the event magnitude, in which case the Analyst is informed, and this subflow ends, and returns to the Main Flow.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1659: [*Threshold*] The System shall provide the Analyst the capability to run event hypothesis magnitude estimate calculations with user selected input parameters.

S-1660: [*Threshold*] The System shall provide the Analyst the capability to select the type of magnitude to compute.

S-1661: [*Threshold*] The System shall provide the Analyst the capability to select the defining/non-defining state for a station magnitude estimate used for network magnitude estimation unless prohibited by the default defining/non-defining state.

S-1811: [*Threshold*] The System shall provide the Analyst the capability to select the earth model used for an earth model prediction.

S-1812: [*Threshold*] The System shall provide the Analyst the capability to select the correction surface used for correcting an earth model prediction.

S-1813: [*Threshold*] The System shall provide the Analyst the capability to apply Master Event Corrections.

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-5621: [*Threshold*] The System shall by default invoke the same algorithms during interactive processing as those used in automated processing.

S-5852: [*Extensibility*] The System shall provide the Analyst the capability to view the model parameters used to predict signal propagation.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Event Magnitude, Network - An estimate of the size of a seismic event determined by combining the set of available station event magnitudes (see event magnitude, station). Separate network event magnitudes can be calculated for each available station magnitude type (e.g., mb, Ms).

Event Magnitude, Station - An estimate of the size of a seismic event determined by processing the waveform data recorded by one station. Separate station event magnitudes can be calculated for different magnitude types (e.g., mb, Ms).

Magnitude Type - A particular magnitude estimation method based on a specified phase, frequency band, and instrument.

Maximum Likelihood Magnitude Estimation (MLE) - A method of estimating the magnitude of an event using information from both detecting and non-detecting stations. For the latter, an amplitude measurement is made at the theoretical arrival time of the phase used for the type of magnitude being calculated (see magnitude type); the assumption is that the amplitude for that phase from the event must be less than or equal to the amplitude measured at the theoretical arrival time.

Station Magnitude - See event magnitude, station.

IDC Specific:
None.

NOTES

General:
1. Overriding station magnitude parameters must be handled individually, not as part of the network magnitude calculation.

2. The types of single-station and network magnitudes that the System can compute include but are not limited to: ML, mb, MS, mbMLE, MSMLE, MSVMAX, Mwcoda, mbrel and infrasound magnitudes.

IDC Specific:
None.

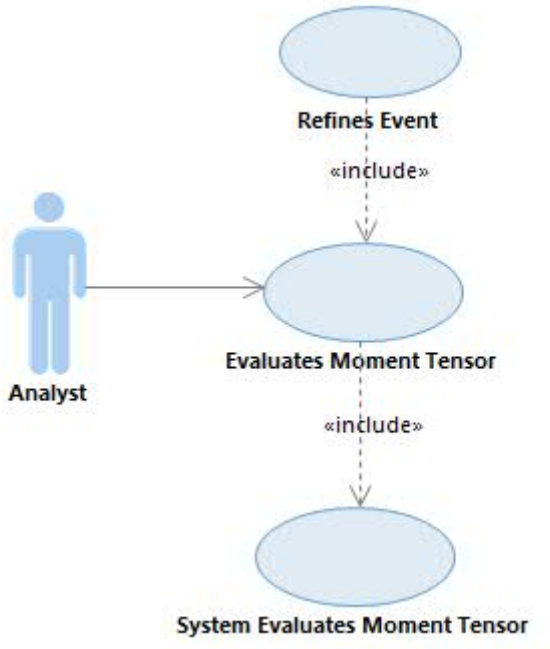
OPEN ISSUES

None.

IDC Use Case Report

UC-03.02.07 Evaluates Moment Tensor

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the Analyst evaluates the moment tensor for an event. The Analyst determines which observed waveforms, stations, location depths, and frequency bands to use to calculate the moment tensor inversion. The Analyst invokes the System to calculate modeled waveforms and the moment tensor (see 'System Evaluates Moment Tensor' UC). The Analyst evaluates the waveform fits and the moment tensor results and recalculates the moment tensor with adjusted parameters as needed.

ACTOR DESCRIPTIONS

Analyst - The Analyst is a System User who analyzes events. This actor includes all the traditional analysis roles. Any Analyst can access all System event analysis capabilities from a use case perspective. Individual analyst capabilities may be further specified by operations procedures.

PRECONDITIONS

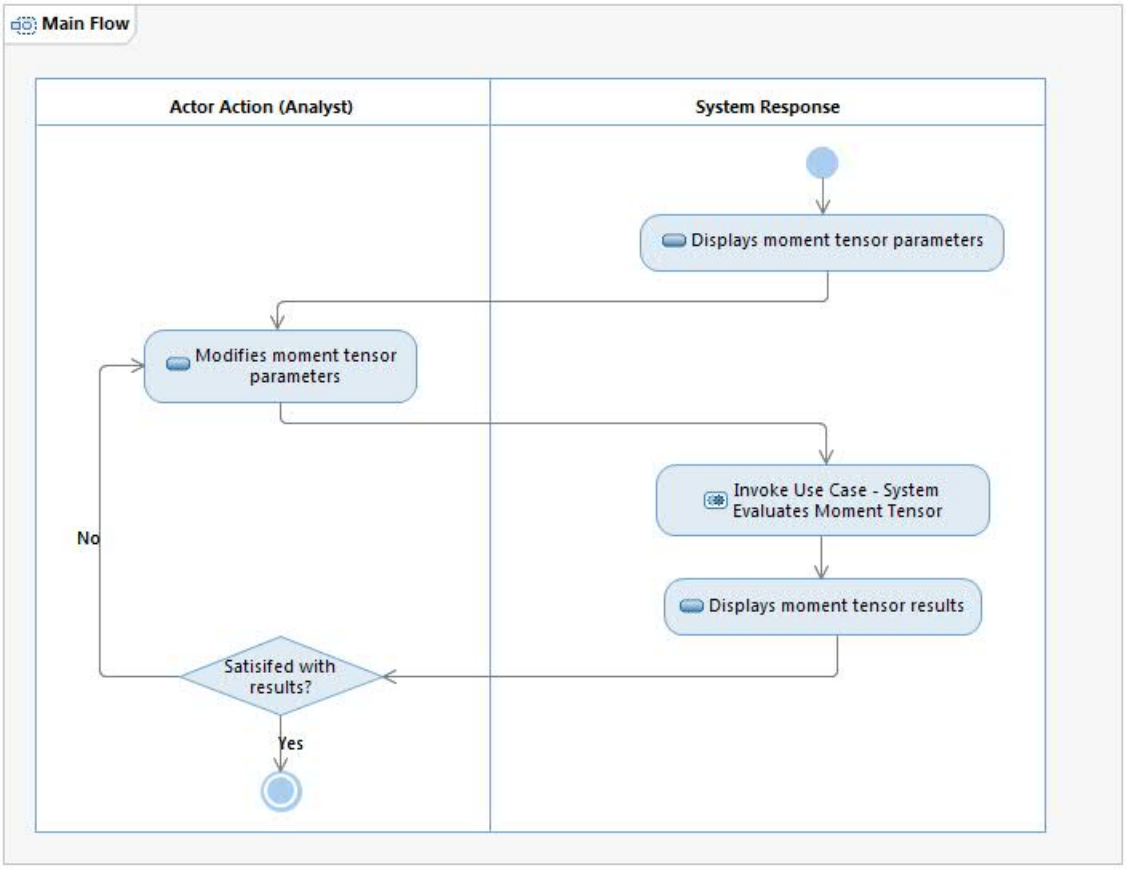
None.

POSTCONDITIONS

None.

ACTIVITY DIAGRAMS

Main Flow



Action Descriptions

Action: "Displays moment tensor parameters"

The System displays the moment tensor parameters described in the 'System Evaluates Moment Tensor' UC.

- Event hypothesis
- Stations and channels to include in the calculation (this could be aided by a plot of station distribution by azimuth and distance)
- Weighting for stations to include in the calculation
- Frequency band for waveform fits
- Observed waveform windows
- Earth models for Green function calculations (potentially station specific)
- Set of location depths spanning the hypothesized depth (this could be aided by a depth sensitivity display)

These moment tensor parameters are either the default parameters if this is the first moment tensor calculation for this event, or the most recent set if a moment tensor has already been calculated. If the moment tensor has already been calculated, the System also displays the moment tensor results. The System Maintainer configures the default values for calculating moment tensor (see 'Configures Processing Components' UC).

Action: "Modifies moment tensor parameters"
The Analyst selects the inputs to the moment tensor calculation.

Action: "Invoke Use Case - System Evaluates Moment Tensor"
The System invokes the 'System Evaluates Moment Tensor' UC to calculate the modeled waveforms and moment tensor for the event hypothesis using Analyst-specified input parameters.

Action: "Displays moment tensor results"
The System displays the results of the moment tensor calculation, including the parameters used in the moment tensor calculation.

Display information includes:
- Modeled waveforms overlain on observed waveforms for tangential, radial, and vertical rotations for different frequency bands.
- A summary of the waveform fits as a single number representing variance reduction of the difference between observed and synthetic waveforms
- Moment tensor, including decomposition information: isotropic components (explosion), deviatoric components (non-explosion), double couple (DC) component (beach ball style plot for DC orientation to see orientation of fault plane and direction of motion along the fault plane), and compensated linear vector dipole (CLVD) component
- Direct estimate of moment / energy released by the event
- Depth fits

The System displays source characterization information. The information displayed should aid the Analyst in interpreting the source information by making it clear how the currently analyzed event fits with moment tensor information for historic events. This information includes source characteristic plots for the current event and historical events - e.g., Hudson diagram (including 95% confidence region), spherical Eigenvalue (including lune plot). The Analyst interacts with the source characterization display to better understand the source information provided by the Moment Tensor. The Analyst may change the type of plot, the confidence level used to show uncertainty, or the set of events added to an event catalog that are shown.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to 'Refines Event' UC.

2. Any Actor Action - The Analyst may undo/redo previous actions.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1706: [*Objective / Priority 1*] The System shall provide the Analyst the capability to compute a moment tensor solution for a selected event hypothesis and collection of seismic stations.

S-1707: [*Objective / Priority 1*] The System shall provide the Analyst the capability to view the theoretical waveform overlaid on the observed waveform for a moment tensor solution.

S-1708: [*Objective / Priority 1*] The System shall provide the Analyst the capability to view the station specific goodness of fit between theoretical and observed waveforms for moment tensor solutions.

S-1709: [*Objective / Priority 1*] The System shall provide the Analyst the capability to view double couple focal mechanisms.

S-1728: [*Objective / Priority 1*] The System shall provide the Analyst the capability to select the number of samples to use during bootstrap resampling on moment tensor solutions to estimate the distributions of ε and k.

S-1729: [*Objective / Priority 1*] The System shall provide the Analyst the capability to select the confidence level used to compute uncertainty bounds on ε and k for a moment tensor solution.

S-1730: [*Objective / Priority 1*] The System shall provide the Analyst the capability to view transformed source type plots for moment tensor solutions as described in Hudson, Pearce, and Rogers (1989).

S-1731: [*Objective / Priority 1*] The System shall provide the Analyst the capability to view the uncertainty bound on ε and k in transformed source type plots.

S-1732: [*Objective / Priority 1*] The System shall provide the Analyst the capability to view multiple moment tensor solutions and their associated uncertainty bounds on ε and k on the same transformed source type plot.

S-1733: [*Objective / Priority 1*] The System shall provide the Analyst the capability to select a group of event hypotheses for which moment tensor solutions and their associated uncertainty bounds on ε and k are plotted on a transformed source type plot.

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-5621: [*Threshold*] The System shall by default invoke the same algorithms during interactive processing as those used in automated processing.

IDC Specific:
None.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Compensated Linear Vector Dipole - The sub-portion of the deviatoric component of the moment tensor remaining after subtraction of the double couple component.

Deviatoric Component (of Moment Tensor) - The portion of the moment tensor remaining after subtraction of the isotropic component. The moment tensor for an idealized earthquake has only a deviatoric component.

Double Couple Component (of Moment Tensor) - The sub-portion of the deviatoric component of the moment tensor that represents two paired but opposing force couples.

Focal Mechanism - A representation of the deformation in the source region of a seismic event. The focal mechanism is diagnostic of the type of event (earthquake or explosion).

Focal Sphere Plot - A plot of the focal mechanism for a seismic event that emphasizes the direction of motion of the P wavefront (away from or towards the event). Focal sphere plots are sometimes referred to as “beach ball” plots. In the case of an earthquake, the focal sphere plot makes evident the orientation and displacement of the fault.

Green Function - The modeled ground motion at one location produced by a unit force at another location. For moment tensor inversion, it is necessary to calculate Green functions corresponding to each of the fundamental force couples in the moment tensor for each seismic station.

Isotropic Component (of Moment Tensor) - The portion of the moment tensor that represents a purely explosive/implosive source. The moment tensor for an idealized explosion has only an isotropic component.

Moment - The amount of energy released by a seismic event. Moment is the scalar size of the moment tensor.

Moment Tensor - A 3 x 3 matrix of the 9 fundamental force couples that describe the focal mechanism for a particular event. A moment tensor can be decomposed into various components to provide insight into the focal mechanism. The most basic decomposition is into isotropic and deviatoric components.

Moment Tensor Inversion - The process of determining the values of the force couples in the moment tensor. Moment tensor inversion is based on fitting the observed waveforms at a set of seismic stations with modeled waveforms based on a sum of the properly scaled Green functions. The scaling factors are the elements of the moment tensor.

Radiation Pattern - A geometric description of the amplitude and direction of motion for the P and S wavefronts near the source.

Source Type Plot - A plot used to differentiate different types of seismic sources based on their moment tensor decompositions. The coordinates of a source type plot are based on parameters derived from the relative size of the moment tensor components.

IDC Specific:
None.

NOTES

General:
None.

IDC Specific:
None.

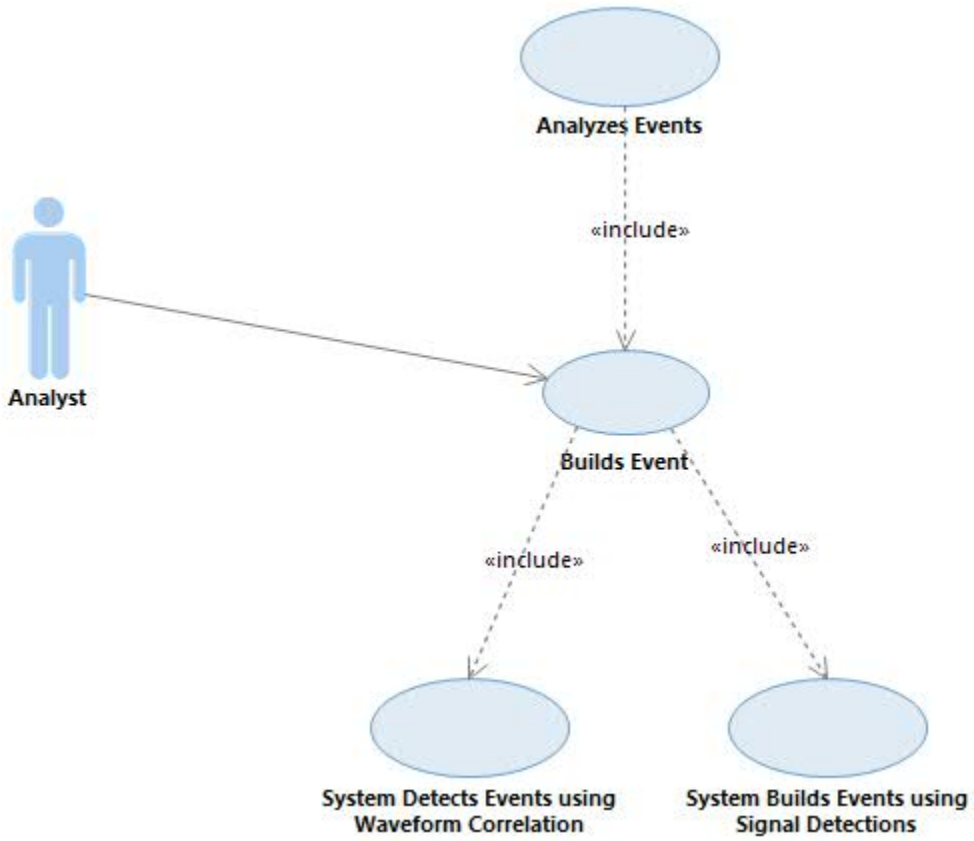
OPEN ISSUES

None.

IDC Use Case Report

UC-03.04 Builds Event

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the Analyst builds a new event hypothesis missed by prior processing. The Analyst builds event hypotheses using the following methods: manual signal association, invoking waveform correlation algorithms, invoking signal association algorithms, and specifying an event time and location to build a virtual event hypothesis.

The Analyst manually builds a new event hypothesis by finding collections of signal detections representing observations of the same event and associating those signal detections as a new event hypothesis.

The Analyst invokes waveform correlation and signal association algorithms, including the same algorithms used in pipeline processing (see 'System Detects Events using Waveform Correlation' UC and 'System Builds Events using Signal Detections' UC), but the Analyst has

the option to select the input parameters rather than the predefined parameters used during pipeline processing.

The Analyst builds a virtual event hypothesis for a specified time and location by first creating an event hypothesis with no associated signal detections and then using Analyst tools (see 'Refines Event' UC) to find evidence supporting existence of an event at that time/location.

The System indicates to the Analyst if an event hypothesis does not meet event formation criteria configured by the System Maintainer (see 'Configures Processing Components' UC). The Analyst views event quality metrics computed by the System for all Analyst built event hypotheses.

ACTOR DESCRIPTIONS

Analyst - The Analyst is a System User who analyzes events. This actor includes all the traditional analysis roles. Any Analyst can access all System event analysis capabilities from a use case perspective. Individual analyst capabilities may be further specified by operations procedures.

PRECONDITIONS

1. The Analyst has selected data for analysis (see 'Selects Data for Analysis' UC) and is viewing the selected data.

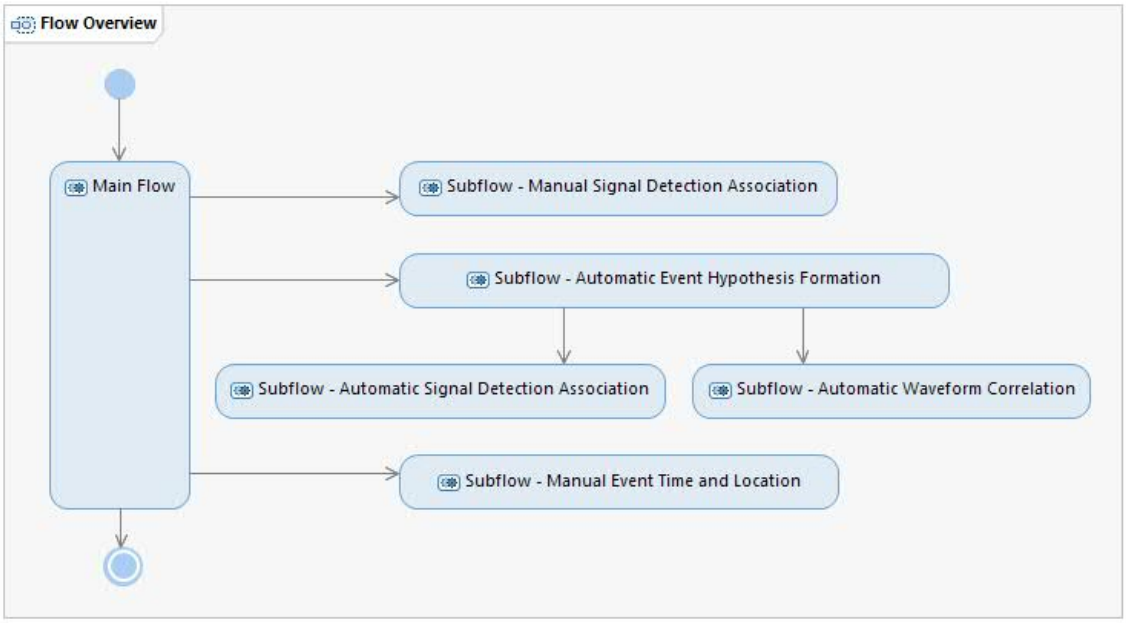
POSTCONDITIONS

1. New event hypotheses may be created.

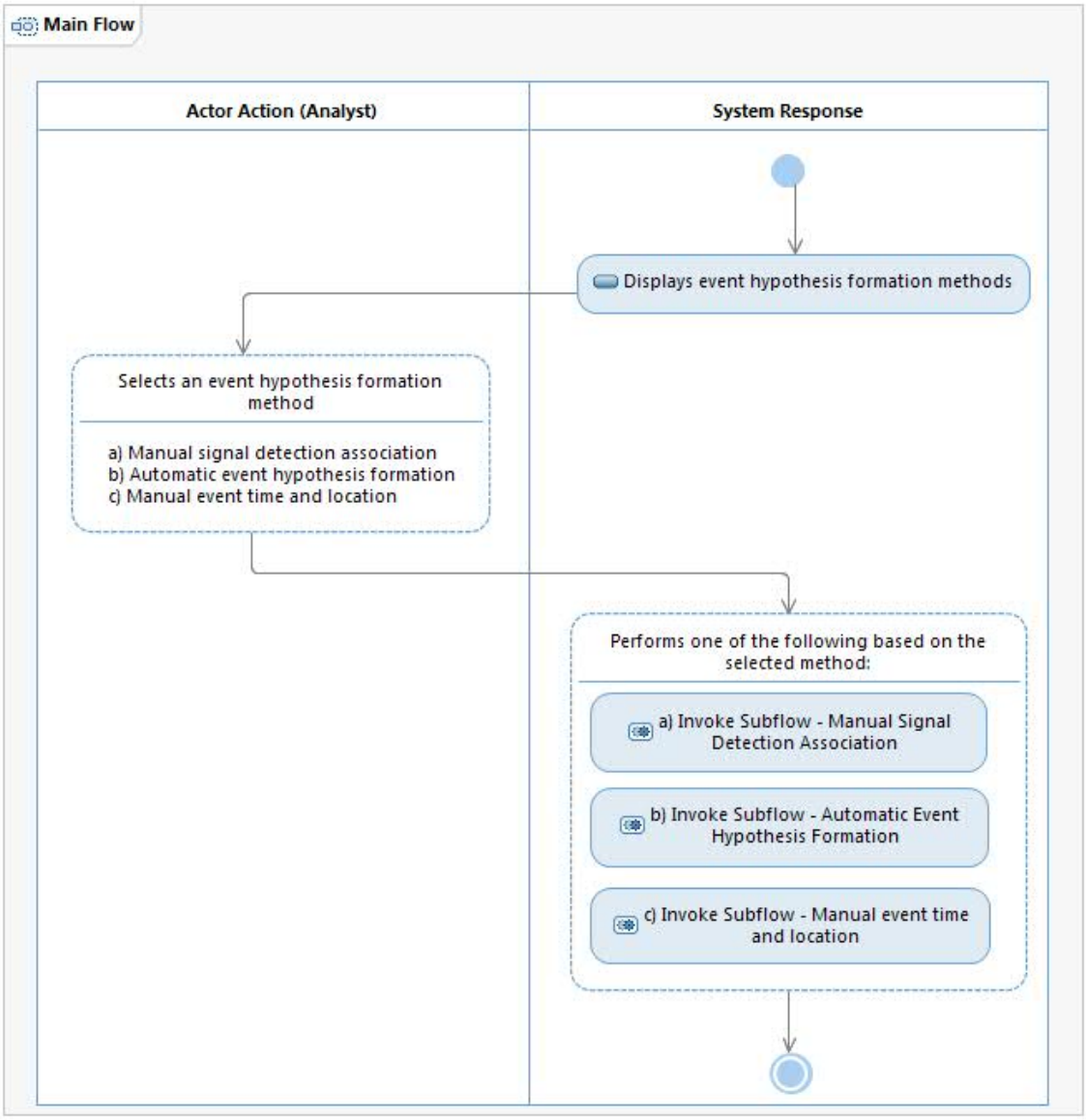
2. Existing event hypotheses may be modified or rejected.

ACTIVITY DIAGRAMS

Flow Overview



Main Flow



Action Descriptions

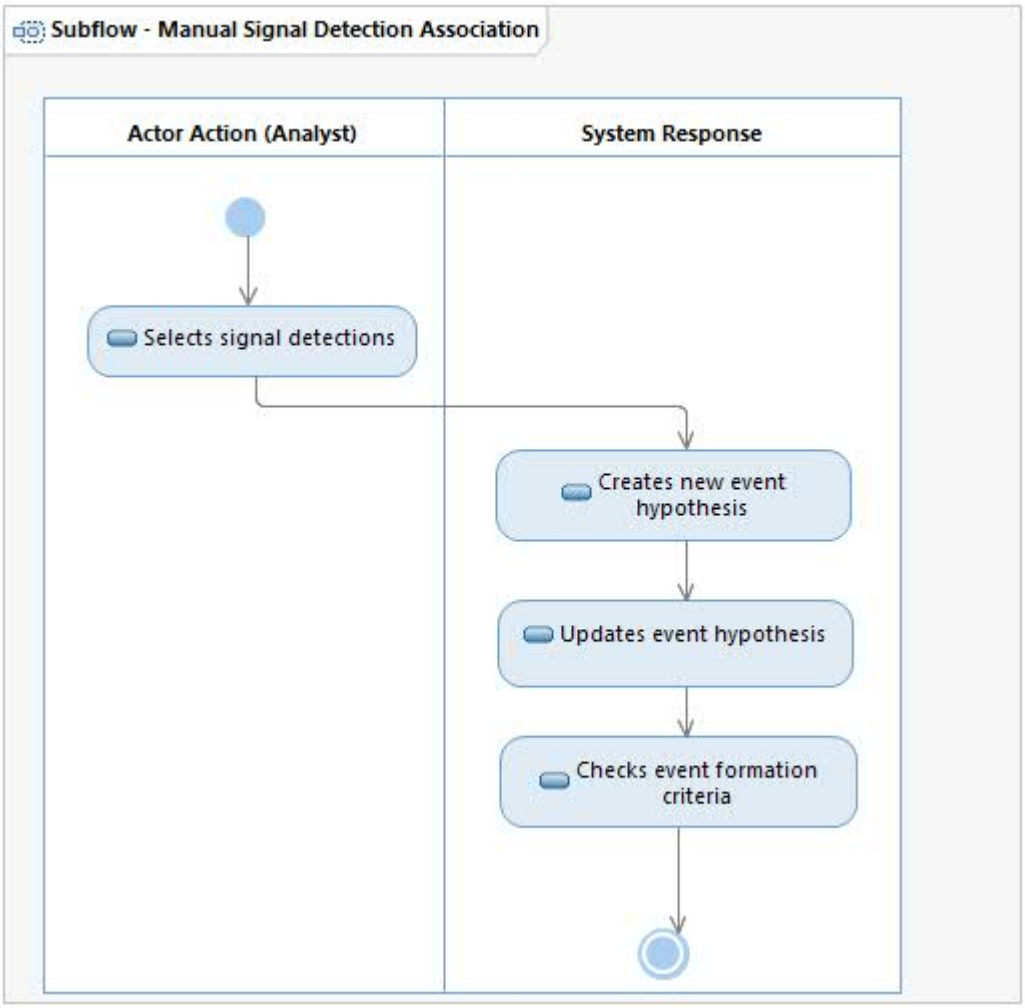
None.

Alternate Flows

1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to the calling UC, either 'Analyzes Events' or 'Scans Waveforms and Unassociated Detections'.

2. Any Actor Action - The Analyst may undo previous actions.

Subflow - Manual Signal Detection Association



Action Descriptions

Action: "Selects signal detections"

The Analyst specifies which unassociated signal detections to associate with the event hypothesis.

Action: "Creates new event hypothesis"

The System creates a new event hypothesis, associates it with the selected signal detections, and computes an initial event location.

Action: "Updates event hypothesis"

The System updates information for the event hypothesis such as magnitude, etc. The System computes the station quality metric, station probability of detection, and the event quality metric. The specific information that is updated here is configured by the System Maintainer (see 'Defines Processing Sequence' UC).

Action: "Checks event formation criteria"

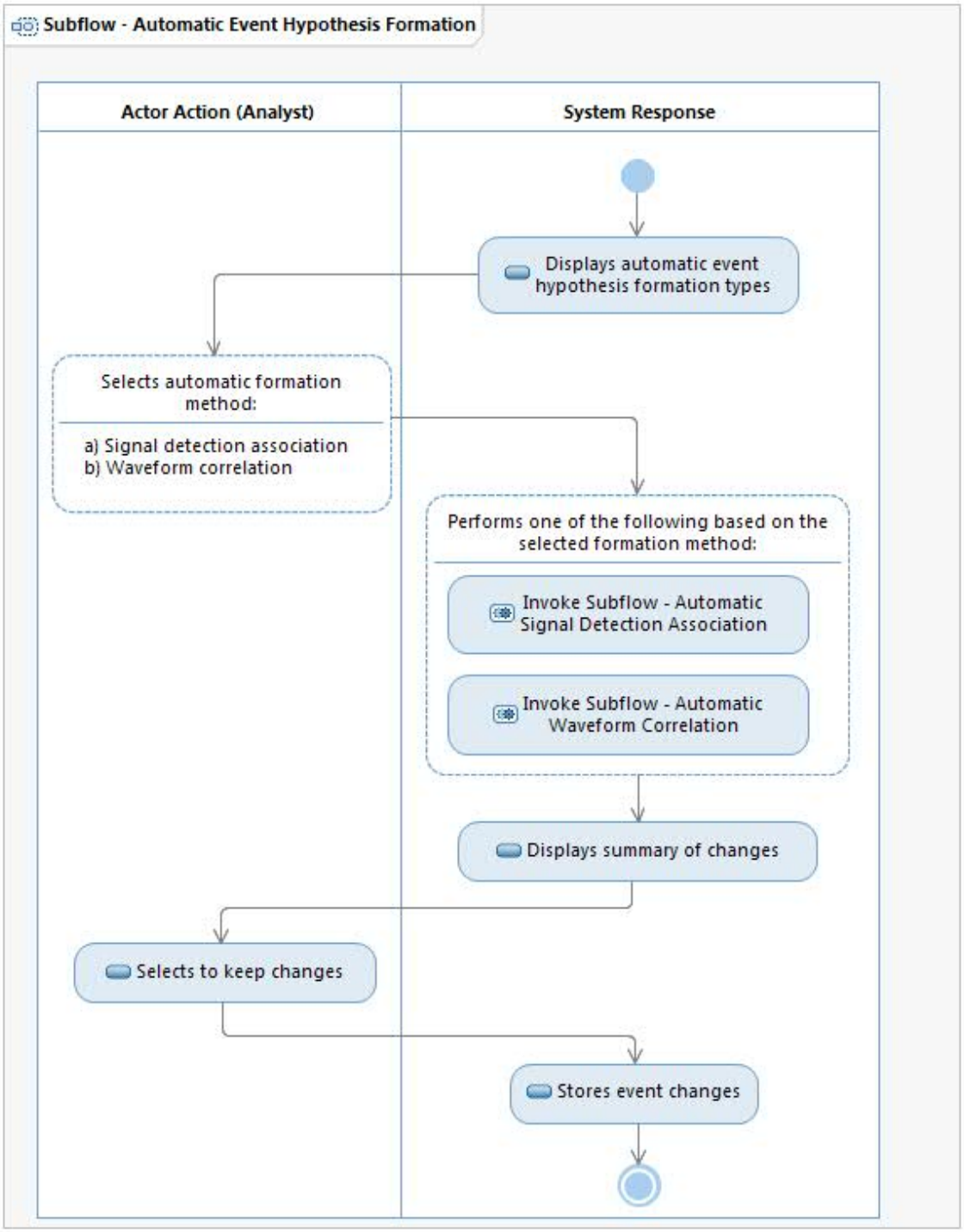
The System checks the new event hypothesis against the default event formation criteria (e.g., minimum number of detections) and informs the Analyst of any criteria that are unmet.

Alternate Flows

1. Action "Selects signal detections" - The Analyst may choose to cancel, in which case this flow ends, and returns to the Main Flow.

2. Action "Selects signal detections" - The Analyst may undo/redo selections.

Subflow - Automatic Event Hypothesis Formation



Action Descriptions

Action: "Performs one of the following based on the selected formation method:"

The System invokes the appropriate subflow to build events by rerunning portions of the automatic processing pipeline. As part of each subflow the System may build, modify or reject events. However, the System does not store the changes in this step since the Analyst has the option to keep or discard the changes (as shown on the subsequent steps).

Action: "Displays summary of changes"
The System displays a summary of the event hypotheses that it created, modified or rejected. The System displays summary information about each affected event hypothesis (e.g., location, magnitude, event quality metrics) and the actions it performed.

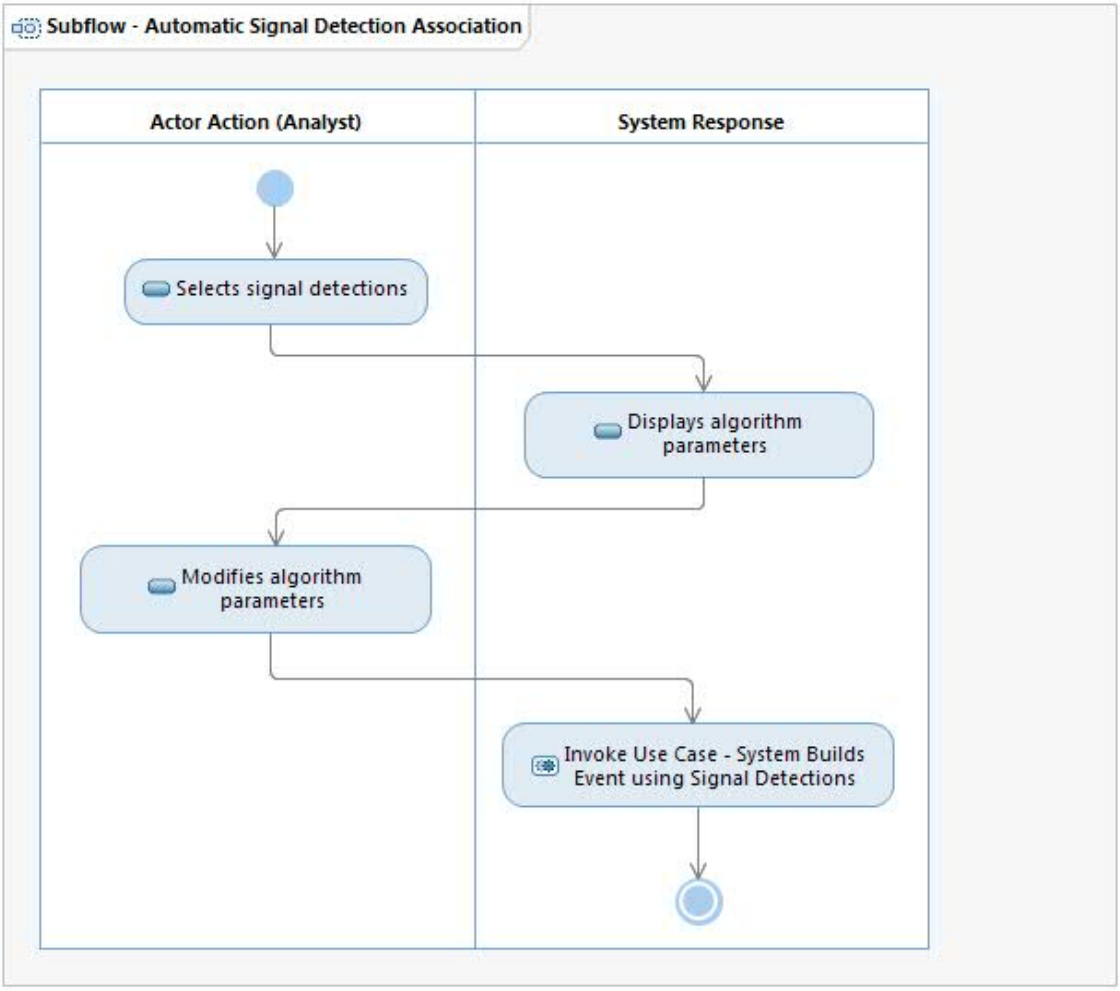
Action: "Selects to keep changes"
The Analyst selects to permanently keep the set of changes.

Action: "Stores event changes"
The System stores the created, modified, and rejected event hypotheses.

Alternate Flows
1. Action "Selects automatic formation method:" - The Analyst may choose to cancel, in which case this flow ends, and returns to the Main Flow.

2. Action "Selects to keep changes" - The Analyst may choose to discard the changes instead, in which case the flow ends, and returns to the Main Flow. In this case the changes identified by running automatic event hypothesis formation are not applied.

Subflow - Automatic Signal Detection Association



Action Descriptions

Action: "Selects signal detections"

The Analyst selects which detections to use by selecting individual detections or all unassociated detections.

Action: "Displays algorithm parameters"

The System displays the following and provides the Analyst with the ability to modify them for this run:

1. The default signal association event hypothesis formation criteria
2. The signal detection templates the System uses to search for event hypotheses.
3. The default event quality thresholds for forming new events, recreating Analyst-rejected events, and modifying Analyst-reviewed events
4. The default parameters for computing event location
5. The default parameters for computing event magnitude
6. The set of stations used for forming a new event

The above defaults are all configured by the System Maintainer (see 'Configures Processing Components' UC). If the Analyst is building a new event, the System displays the signal detection template the System uses to search for event hypotheses. After an event hypothesis exists, the Analyst may apply additional signal detection templates.

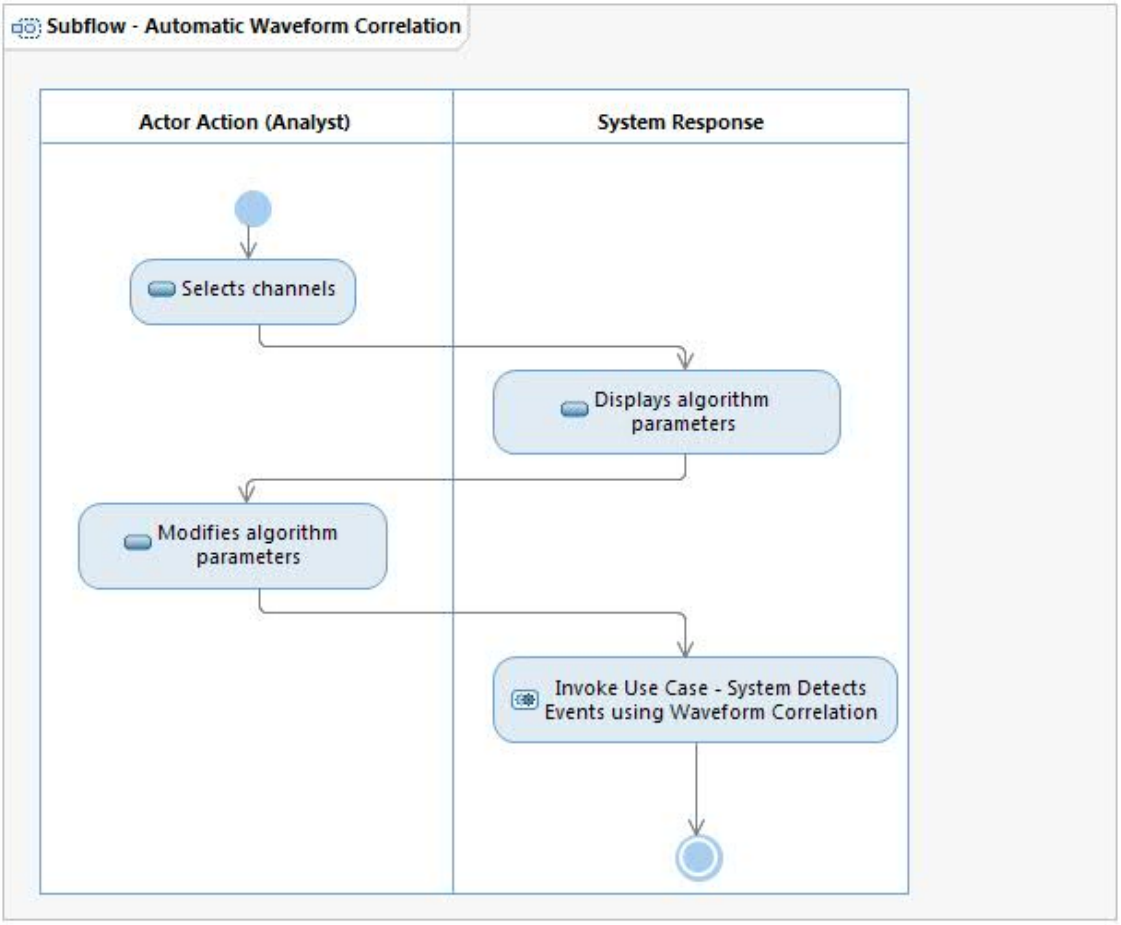
Action: "Modifies algorithm parameters"
The Analyst modifies the algorithm parameters for the run. The modified parameters are used only within the context of this flow (i.e., the default parameters configured by the System Maintainer are not affected).

Action: "Invoke Use Case - System Builds Event using Signal Detections"
The System invokes the 'System Builds Events using Signal Detections' UC using the specified signal detections, specified signal detection event hypothesis formation criteria and event quality thresholds, and existing event hypotheses for the current time interval. The System may create, modify or reject any number of new event hypotheses in this step. Note that the create/modify/reject actions do not affect the state of the System in this step, since the Analyst is allowed to review the changes and possibly cancel without affecting the state of the System (shown in the invoking flow).

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this flow ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

Subflow - Automatic Waveform Correlation



Action Descriptions

Action: "Selects channels"

The Analyst selects which channels to use by selecting individual channels or all available channels.

Action: "Displays algorithm parameters"

The System displays the following parameters and provides the Analyst with the ability to modify them for this run:

1. The default waveform correlation parameters
2. The default event quality thresholds for forming new events, recreating Analyst-rejected events, and modifying Analyst-reviewed events
3. The default parameters for resolving event conflicts.
4. The default parameters for computing event location
5. The default parameters for computing event magnitude

The above defaults are all configured by the System Maintainer (see 'Configures Processing Components' UC).

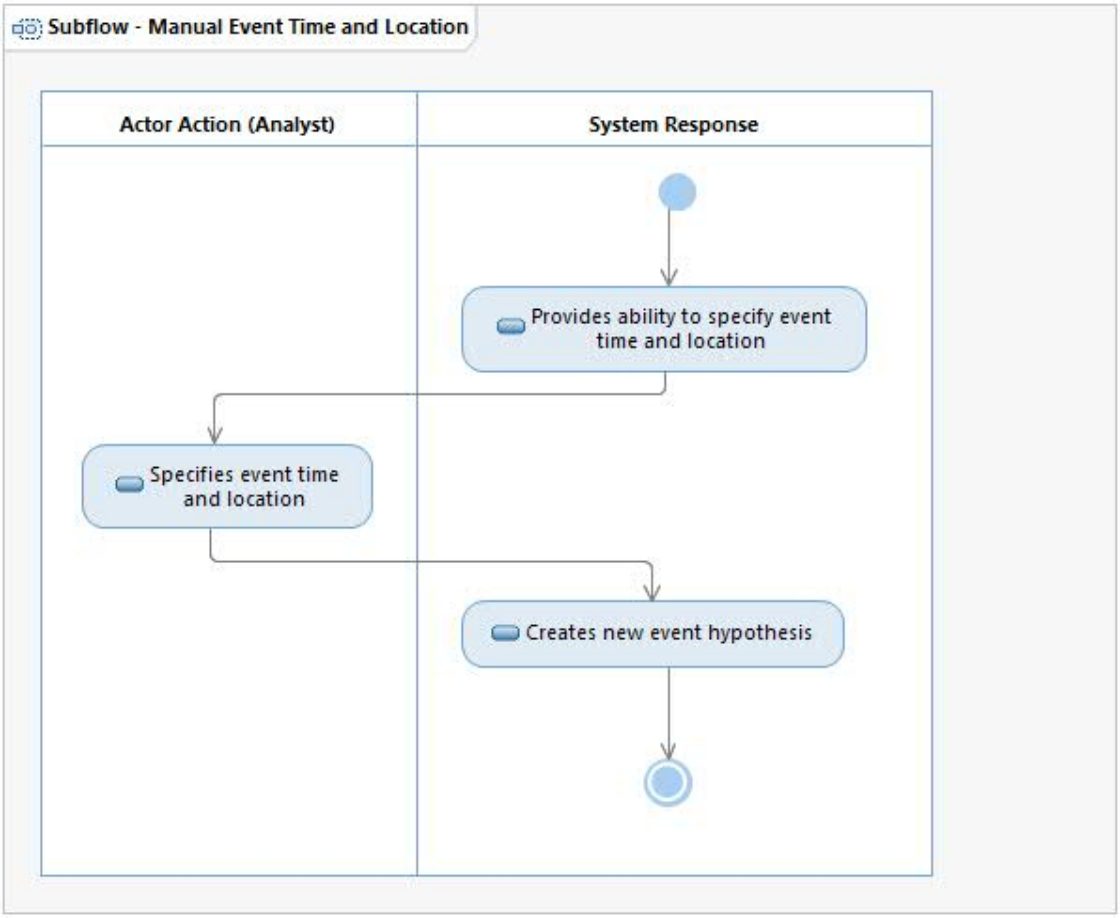
Action: "Modifies algorithm parameters"
The Analyst modifies the algorithm parameters for the run. The modified parameters are used only within the context of this flow (i.e., the default parameters configured by the System Maintainer are not affected).

Action: "Invoke Use Case - System Detects Events using Waveform Correlation"
The System invokes the 'System Detects Events using Waveform Correlation' UC using the specified channels and waveform correlation parameters. The System may create any number of new event hypotheses in this step.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this flow ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

Subflow - Manual Event Time and Location



Action Descriptions
Action: "Provides ability to specify event time and location"
The System provides the ability to specify location parameters for a new event hypothesis: latitude, longitude, depth, and time.

Action: "Specifies event time and location"
The Analyst specifies the latitude, longitude, depth, and time for the event hypothesis.

Action: "Creates new event hypothesis"
The System creates a new event hypothesis with the Analyst provided time and location.

Alternate Flows
1. Any Actor Action - The Analyst may choose to cancel, in which case this use case ends, and returns to the Main Flow.

2. Any Actor Action - The Analyst may undo/redo previous actions.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1157: [*Objective / Priority 2*] The System shall provide the Analyst the capability to view newly acquired waveform data within 1 minute of acquisition.

S-1533: [*Threshold*] The System shall provide the Analyst the capability to invoke algorithms and parameters used during automated processing for the generation of new event hypotheses for evaluation.

S-1534: [*Threshold*] The System shall provide the Analyst the capability to select the signal association event hypothesis formation criteria.

S-1536: [*Threshold*] The System shall provide the Analyst the capability to form new event hypotheses from unassociated signal detections.

S-1537: [*Threshold*] The System shall provide the Analyst the capability to create a virtual event hypothesis (an event hypothesis with no associated signal detections).

S-1554: [*Threshold*] The System shall set to non-defining newly associated signal detections when the Analyst invokes automated processing algorithms to associate signal detections to existing event hypotheses.

S-1572: [*Threshold*] The System shall compute the station quality metric for all events.

S-1576: [*Threshold*] The System shall store the station quality metrics for all stations for each event hypothesis.

S-1579: [*Threshold*] The System shall compute an event hypothesis quality metric using the event hypothesis quality statistics for each event hypothesis formed on the System.

S-1588: [*Threshold*] The System shall store the event quality metric for each event hypothesis.

S-1877: [*Threshold*] The System shall notify Analysts working in a common processing stage if they are concurrently modifying signal detections in the same analysis time interval.

S-1878: [*Threshold*] The System shall provide the Analyst the capability to access and view all waveform data stored on the System.

S-1915: [*Threshold*] The System shall provide the Analyst the capability to process data without altering another Analyst's existing solution.

S-1927: [*Threshold*] The System shall provide the Analyst the capability to select signal detections as processing input based on a time interval for an entire network during an analysis session.

S-1928: [*Threshold*] The System shall provide the Analyst the capability to select signal detections as processing input based on a time interval for a selected subset of stations during an analysis session.

S-1929: [*Threshold*] The System shall provide the Analyst the capability to individually select signal detections as processing input during an analysis session.

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2036: [*Threshold*] The System shall use configured default defining/non-defining state settings and precedence rules to determine the initial defining/non-defining state for each parameter.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2164: [*Threshold*] The System shall access requested waveform data within one (1) minute of receipt by the Data Processing Partition.

S-2167: [*Threshold*] The System shall write a 6 hour or less time block of 40Hz waveform data within the Operational Processing Time Period with a maximum 5 second latency. (Goal: 1 second.)

S-2168: [*Threshold*] The System shall read a 6 hour or less time block of 40Hz waveform data outside the Operational Processing Time Period with a maximum 10 second latency. (Goal: 2 seconds.)

S-2169: [*Threshold*] The System shall read a 6 hour or less time block of 40Hz waveform data within the Operational Processing Time Period with a maximum 5 second latency. (Goal: 1 second.)

S-2170: [*Threshold*] The System shall write a 6 hour or less time block of 40Hz waveform data outside the Operational Processing Time Period with a maximum 10 second latency. (Goal: 2 seconds.)

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-2603: [*Threshold*] The System shall provide the System User the capability to access requested waveform data.

S-2604: [*Threshold*] The System shall provide the Analyst the capability to access late-arriving waveform data within one (1) minute of receipt by the Data Processing Partition.

S-2607: [*Threshold*] The System shall provide the Analyst the capability to recreate previously rejected event hypotheses as a result of invoking automated processing algorithms only when the event quality metric for the automatic event hypothesis improves more than a configured threshold.

S-3023: [*Objective / Priority 1*] The System shall provide the Analyst the capability to define signal detection templates for automatic event hypothesis formation.

S-3024: [*Threshold*] The System shall provide the Analyst the capability to build events using a selected signal detection template.

S-6010: [*Threshold*] The System shall provide the Analyst the capability to associate signal detections to existing events using signal detection templates.

IDC Specific:
S-5612: [*IDC only, Threshold*] The System shall provide the Analyst the capability to request auxiliary seismic waveform data from the Data Acquisition Partition.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Association - See signal association.

Event - The estimate by the System or Analyst of the occurrence of some transient source of energy within the Earth's body, oceans, or atmosphere that can be detected by seismic, hydroacoustic, and/or infrasonic sensors. For the same event, many different event hypotheses may be created at different processing stages. One of these event hypotheses must be designated as preferred.

Event Hypothesis - A proposed solution for an Event. Each event consists of a sequence of event hypotheses that describe an evolution to a final best model of the event. Each event hypothesis is composed of a set of associated signal detections and has one or more event hypothesis location solutions, one of which must be designated as preferred.

Event Hypothesis Quality Metric - See event quality metric.

Event Quality Metric - A quality metric computed as a number in the closed interval [0.0, 1.0] (low to high) for each event hypothesis formed on the System. This metric indicates the quality of the event hypothesis as a function of the event hypothesis's associated signal detections and related measurements, location solution, station state-of-health, and network state-of-health information. The System computes a new event quality metric whenever any parameter used for calculating the metric is updated and stored.

Reference Event - An event recognized by an analyst as containing unique or important characteristics that may help in the analysis of future events that are related. For example, a nuclear test could be designated as a reference event for any subsequently detected nearby events thought to be tests.

Signal Association - The process of linking (associating) a set of signal detections from a network of stations to an event hypothesis, either existing or new. Association is based on consistency of observed and predicted signal detection feature measurements (e.g., arrival time, azimuth, slowness). Signal association can be done automatically by the system (see pipeline processing), or manually by an analyst.

Signal Detection - A specific interval on a waveform marking the arrival of a signal of interest. Other portions of the waveform are noise.

Signal Detection Template - The set of signal detections associated with an event. The relative timing of the signal detections is indicative of the location of the event. Shifting the timing of a signal detection template, and matching it with signal detections on current waveforms, can help determine whether a similar event has occurred, and aid in identifying and associating signal detections to existing events. These templates can be particularly helpful for building events in an aftershock or swarm sequence.

Virtual Event Hypothesis - A trial event hypothesis created for analyzing waveform and alphanumeric data in an attempt to discover evidence supporting the existence of an actual event.

Waveform Correlation Event Processing - A technique used to find events by matching current waveforms to waveforms of known historical events. Waveform similarity is determined using the correlation coefficient. When a match is found, there is high probability that a new event has occurred, which is of the same source type and near the same location (see event location) as the historical event.

IDC Specific:
None.

NOTES

General:
1. In the case of rerunning automatic signal detection association, the System does not invoke 'System Resolves Event Conflicts' UC afterward because Analysts would prefer to find and resolve any conflicts manually.

2. The processing sequence can be configured to perform additional processing after an Analyst invokes automatic processing to build new events. The processing sequence may include 'System Resolves Event Conflict' UC, 'System Refines Event Location' UC, and 'System Refines Event Magnitude' UC.

3. After an event is built the Analyst may refine the event using 'Refines Event' UC.

4. The System sets default defining states based on rules previously configured by the System Maintainer (see 'Configures Processing Components' UC).

IDC Specific:
None.

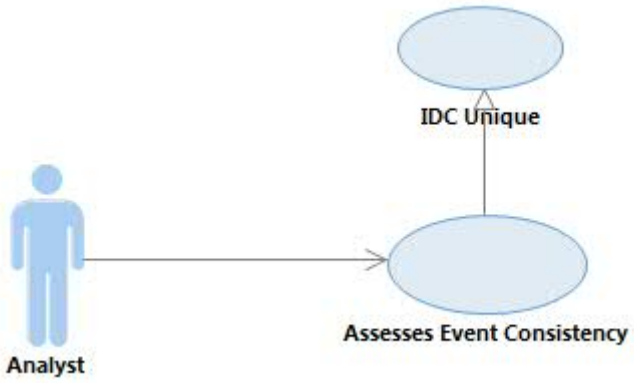
OPEN ISSUES

None.

IDC Use Case Report

UC-14.01 Assesses Event Consistency

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the Analyst assesses the consistency of event characteristics (e.g., signal detection observations, location parameters) by comparing them with expected values. The Analyst selects an event or set of events. The System calculates any event characteristics needed for assessing event consistency and compares the event characteristics against expected values to quantify inconsistencies. The Analyst reviews the summary of inconsistencies. The event characteristics that are calculated and the expected values are configured by the System Maintainer (see 'Configures Processing Components' UC).

ACTOR DESCRIPTIONS

Analyst - The Analyst is a System User who analyzes events. This actor includes all the traditional analysis roles. Any Analyst can access all System event analysis capabilities from a use case perspective. Individual analyst capabilities may be further specified by operations procedures.

PRECONDITIONS

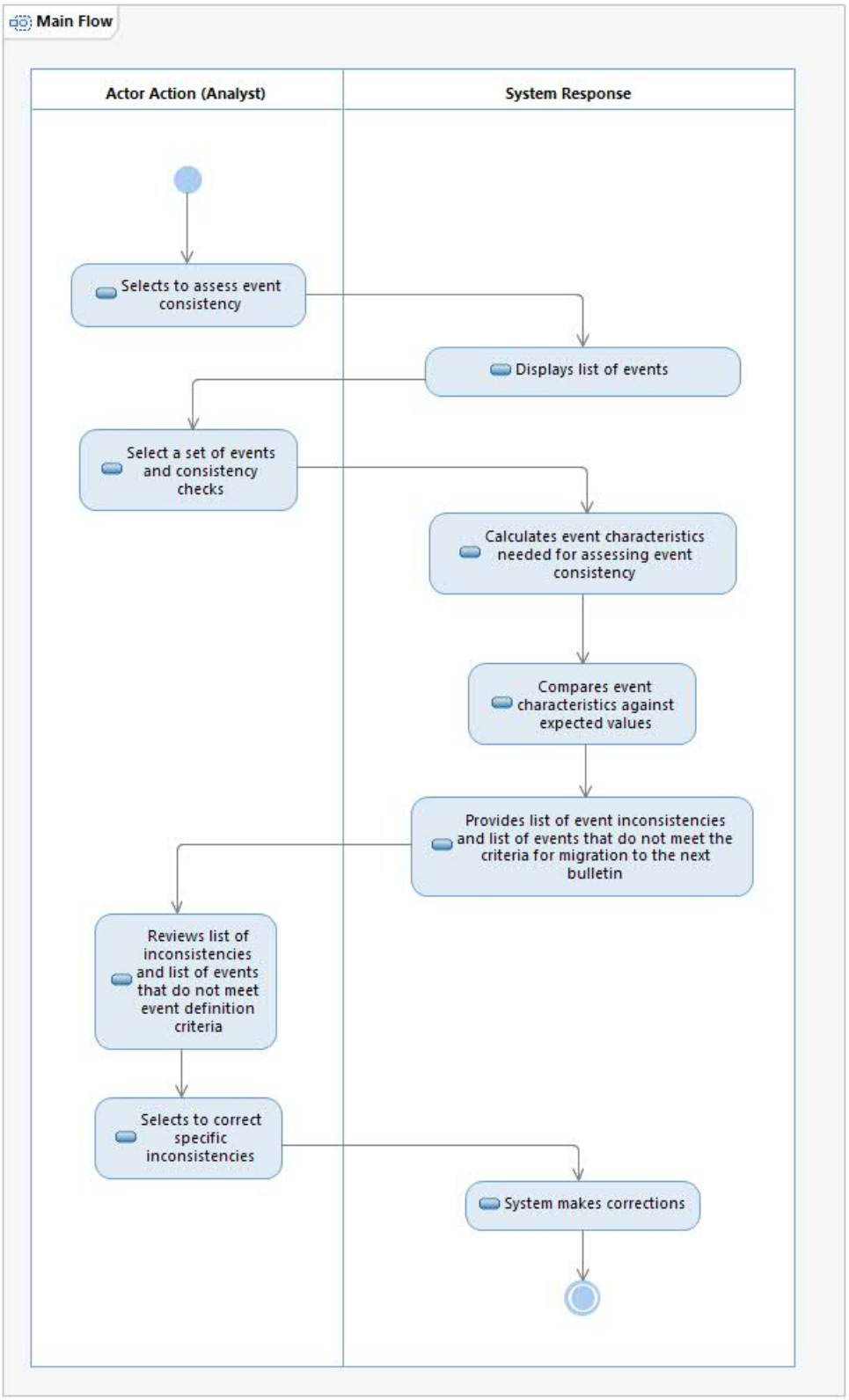
None.

POSTCONDITIONS

None.

ACTIVITY DIAGRAMS

Main Flow



Action Descriptions

Action: "Select a set of events and consistency checks"

The Analyst chooses the events to assess for consistency and what consistency checks to make. The Analyst may choose to compute a subset of the event consistency checks.

Action: "Calculates event characteristics needed for assessing event consistency"

The System uses a variety of event characteristics to assess event consistency. The needed information may have been calculated as the event hypothesis was created and saved. The System calculates any required values prior to performing the consistency checks.

Event characteristics include, for example:
- stations that observed the event and how many are primary stations
- the phases of the signal detections associated to the event
- time, azimuth, and slowness residuals and weights for each signal detection
- time, azimuth, and slowness defining settings for each signal detection
- the magnitudes calculated at each station
- the configured network magnitudes

Action: "Compares event characteristics against expected values"

The System checks that the event information is consistent for an event located at the hypothesized source location with the estimated magnitude. The System creates a list of recommended corrections based on the consistency check.

Example consistency checks the System can perform include:
- the observing stations are consistent with the location and magnitude of the event
- the time, azimuth, and slowness defining settings have been set for each signal detection
- time, azimuth, and slowness residuals for defining and non-defining location associated signal detections do not exceed the configured threshold
- all signal detections belonging to a group of hydroacoustic signal detections are associated to the event
- the ordered phases at each observing station are consistent with the configured list of phases for the location and magnitude of the event
- there are no duplicate phases for the associated signal detections at each observing station
- a deep event is located in an area where deep events are known to occur
- the number of location defining signal detections for a deep event meet or exceed the configured threshold
- the difference between ML and mb magnitudes does not exceed the configured threshold
- event definition criteria, including the minimum number of primary stations that have observations, are satisfied for the event hypothesis

Action: "Provides list of event inconsistencies and list of events that do not meet the criteria for migration to the next bulletin"

The System lists the inconsistencies for each event that has been assessed and lists the events that do not meet Event Definition Criteria and will not be migrated to the Reviewed Event Bulletin (REB). The Event Definition Criteria may be based on the event quality metric.

Action: "Reviews list of inconsistencies and list of events that do not meet event definition criteria"
The Analyst reviews the list of inconsistencies and the events that do not meet the Event Definition Criteria. There are some inconsistencies (e.g., make the station magnitude outliers non-defining) that the Analyst can choose to have the System correct automatically. Other inconsistencies may require the Analyst to refine the event to correct them (see 'Refines Event' UC) and then perform this UC again to reassess the event's consistency.

Action: "Selects to correct specific inconsistencies"
The Analyst selects the inconsistencies that can be automatically fixed by the System.

Alternate Flows
Any Actor Action - The Analyst may choose to cancel, in which case this use case ends.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-5621: [*Threshold*] The System shall by default invoke the same algorithms during interactive processing as those used in automated processing.

IDC Specific:
S-5735: [*IDC only, Threshold*] The System shall correct event parameters based on the Event Consistency checks as permitted by the configured settings.

S-5794: [*IDC only, Threshold*] The System shall provide the Analyst the capability to interactively compute a subset of the Event Consistency checks.

S-5795: [*IDC only, Threshold*] The System shall compute Event Consistency checks when an event hypothesis is saved.

S-5796: [*IDC only, Threshold*] The System shall generate an Event Consistency check in less than 3 seconds per event hypothesis.

S-5815: [*IDC only, Threshold*] The System shall include a check of minimum number of primary stations as part of the event consistency calculation.

S-5816: [*IDC only, Threshold*] The System shall perform a check of time, azimuth, and slowness residuals and weights as part of the event consistency calculation.

S-5819: [*IDC only, Threshold*] The System shall perform an event consistency check that the ordered list of phases at each station is consistent with the configured list of phases for the event location and magnitude.

S-5820: [*IDC only, Threshold*] The System shall perform an event consistency check that the difference between ML and mb magnitudes is not larger than a specified threshold.

S-5823: [*IDC only, Threshold*] The System shall include a check of observing stations related to event geographic location and magnitude as part of the event consistency calculation.

S-5824: [*IDC only, Threshold*] The System shall include a check for station magnitude outliers as part of the event consistency calculation.

S-5825: [*IDC only, Threshold*] The System shall include a check for consistency of time, azimuth, slowness defining settings per associated arrival as part of the event consistency calculation.

S-5826: [*IDC only, Threshold*] The System shall perform an event consistency check that the time, azimuth, and slowness residuals for location defining associated signal detections do not exceed the configured thresholds.

S-5841: [*IDC only, Threshold*] The System shall perform an event consistency check that deep events have more than a specified threshold number of location defining signal detections.

S-5843: [*IDC only, Threshold*] The System shall perform an event consistency check that there are no duplicate phases among the associated signal detections at each station.

S-5846: [*IDC only, Threshold*] The System shall perform an event consistency check that a deep event is located in an area where deep events are known to occur.

S-5847: [*IDC only, Threshold*] The System shall perform an event consistency check that if any signal detections belonging to a group of hydroacoustic signal detections is associated to an event, then all signal detections in the group must be associated.

S-5849: [*IDC only, Threshold*] The System shall perform an event consistency check that the time, azimuth, and slowness residuals for location non-defining associated signal detections do not exceed the configured thresholds.

S-6291: [*IDC only, Threshold*] The System shall perform an event consistency check that the event definition criteria, if currently defined, are satisfied for each event hypothesis.

S-6292: [*IDC only, Threshold*] The System shall perform an event consistency check that all event-related information is internally consistent and populated with valid types for each event hypothesis.

S-6293: [*IDC only, Threshold*] The System shall perform an event consistency check that event information is consistent for an event located at the hypothesized source location with the estimated magnitude.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:
None.

IDC Specific:
None.

NOTES

General:
1. The System Maintainer may determine expected values by comparing historical events of comparable size in the same general location.

IDC Specific:
None.

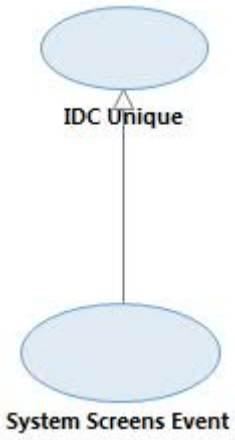
OPEN ISSUES

None.

IDC Use Case Report

UC-14.02 System Screens Events

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the System determines which events are published in the Reviewed Event Bulletin (REB), Standard Event Bulletin (SEB) and Standard Screened Event Bulletin (SSEB). The System uses event definition criteria to determine which events are published in the REB. The System automatically calculates event characteristics for all events in the REB and uses them to score and categorize the events. The calculated event characteristics, their scores and the category of the event are published in the SEB. The System uses the calculated event characteristics to screen out events that are consistent with natural phenomena. The results of the screening process are published in the SSEB. The event definition criteria, event characteristics, and screening criteria are configured by the System Maintainer (see 'Configures Processing Components' UC).

ACTOR DESCRIPTIONS

None.

PRECONDITIONS

None.

POSTCONDITIONS

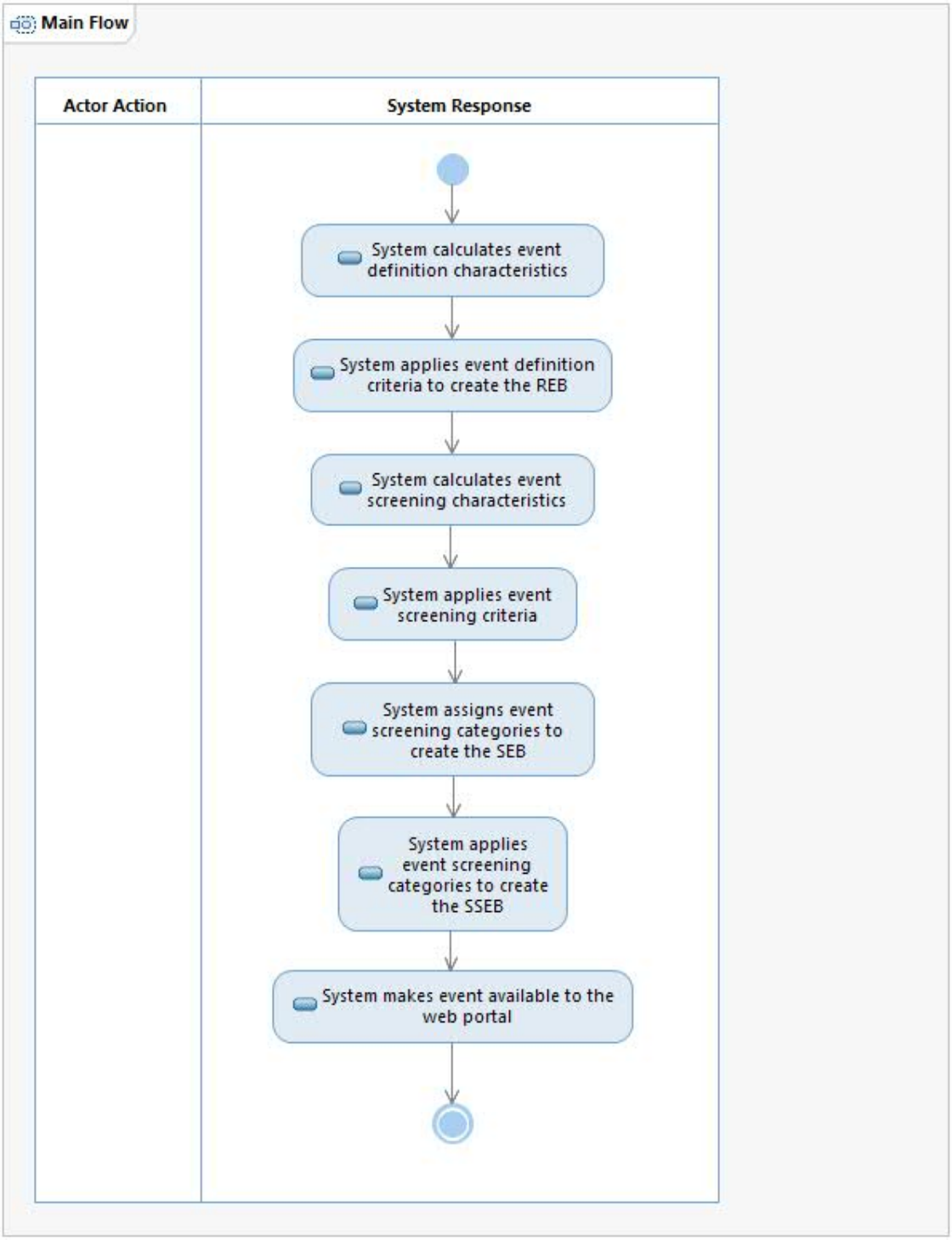
1. Events that meet the event definition criteria are published in the REB.

2. Events published in the SEB have been scored and categorized based on event characteristics.

2. Events that are consistent with natural phenomena have been excluded from the SSEB.

ACTIVITY DIAGRAMS

Main Flow



Action Descriptions

Action: "System calculates event definition characteristics"

The System calculates the event definition characteristics for each Analyst-reviewed event. The event definition characteristics include:
- Sum of the weights of the defining associated arrivals for primary seismic, secondary seismic, hydroacoustic and infrasound stations
- Number of P-type phase measurements at primary seismic stations
- Number of H phase measurements at hydroacoustic stations
- Number of I phase measurements at infrasound stations

Action: "System applies event definition criteria to create the REB"
The System applies the event definition criteria for each Analyst-reviewed event based on the defaults for the event definition characteristics configured by the System Maintainer (see 'Configures Processing Components' UC). The events that pass the event definition criteria are published in the Reviewed Event Bulletin (REB).

Action: "System calculates event screening characteristics"
The System calculates the event screening characteristics for each event in the REB. These event screening characteristics include:
- Teleseismic P-wave complexity
- Regional phase time-domain amplitudes
- Energy ratio
- Spectral and cepstral characteristics
- Third moment of frequency
- Time-frequency characteristics
- First motion
- Hydroacoustic noise for select frequency bands
- Hydroacoustic cepstral peak

Action: "System applies event screening criteria"
The System applies the event screening criteria for each event based on the default defining states configured by the System Maintainer (see 'Configures Processing Components' UC). The event screening criteria include:
- Depth Screening
- Ms:mb Screening
- Regional Seismic P/S Screening
- Hydroacoustic Screening
- Infrasound Screening

The result of this step is a score for each event screening criteria.

Action: "System assigns event screening categories to create the SEB"
Based on the event screening criteria scores, the System assigns each event to one of four event screening categories and one of three location categories. The event screening criteria scores, screening category and location category are added to the information in the REB and published in the Standard Event Bulletin (SEB). The criteria thresholds are configured by the System Maintainer (see 'Configures Processing Components' UC) or the Authorized External User (see 'Requests System Data' UC).

The four screening categories are:
1. Events for which the standard event screening criteria are not applicable (Not Considered)
2. Events that lack adequate event characterization parameters to apply any of the screening criteria (Insufficient Data)
3. Events for which at least one of the screening criteria can be applied, but the criteria are not satisfied (Not Screened Out)
4. Events with at least one of the event screening scores greater than zero (Screened Out)

The three location categories are:
1. Onshore
2. Offshore
3. Mixed

Action: "System applies event screening categories to create the SSEB"
The System publishes the Standard Screened Event Bulletin (SSEB) which includes events that were categorized as "Not Considered", "Insufficient Data" and "Not Screened Out".

Action: "System makes event available to the web portal"
The System publishes the REB, SEB and SSEB to the web portal for users to view and request (see 'Views System Results' UC and 'Requests System Data' UC).

Alternate Flows
None.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-2036: [*Threshold*] The System shall use configured default defining/non-defining state settings and precedence rules to determine the initial defining/non-defining state for each parameter.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

IDC Specific:
S-5744: [*IDC only, Threshold*] The System shall calculate a numerical metric for each configured screening criterion for each event.

S-5745: [*IDC only, Threshold*] The System shall assign an overall screening category based on a combination of the individual screening criteria numerical metric scores.

S-6548: [*IDC only, Threshold*] The System shall calculate event definition criteria for each event based on a weighted count of defining signal detection feature measurements.

S-6549: [*IDC only, Threshold*] The System shall calculate event definition criteria for each event based on the number of configured observation types at specific station types.

S-6550: [*IDC only, Threshold*] The System shall publish events in the Reviewed Event Bulletin (REB) based on the event definition criteria.

S-6552: [*IDC only, Threshold*] The System shall publish events in the Standard Event Lists (SEL1, SEL2, SEL3) based on configuration.

S-6553: [*IDC only, Threshold*] The System shall provide the System Maintainer the capability to configure the criteria used to publish bulletins.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:
None.

IDC Specific:
None.

NOTES

General:
1. Authorized External Users can also request a customized National Standard Event Bulletin (NSEB) and National Standard Screened Event Bulletin (NSSEB) via the web portal. See 'Requests System Data' UC.

IDC Specific:
None.

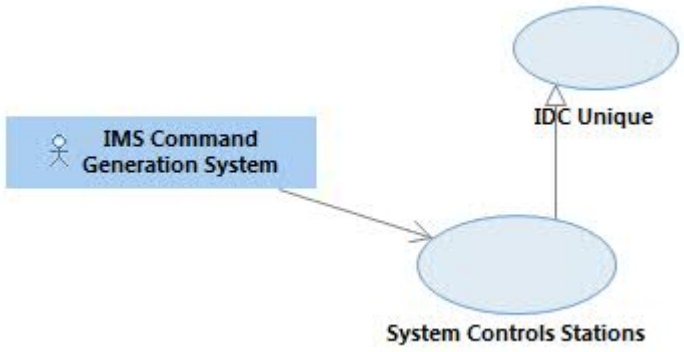
OPEN ISSUES

None.

IDC Use Case Report

UC-14.03 System Controls Stations

USE CASE DIAGRAM



BRIEF DESCRIPTION

This use case describes how the System controls monitoring stations. The System securely issues commands to monitoring stations and monitors response to support sensor calibration, authentication key maintenance, and station diagnostics.

ACTOR DESCRIPTIONS

IMS Command Generation System - The IMS Command Generation System is an external system that sends formatted command and control messages for IMS stations to the System.

PRECONDITIONS

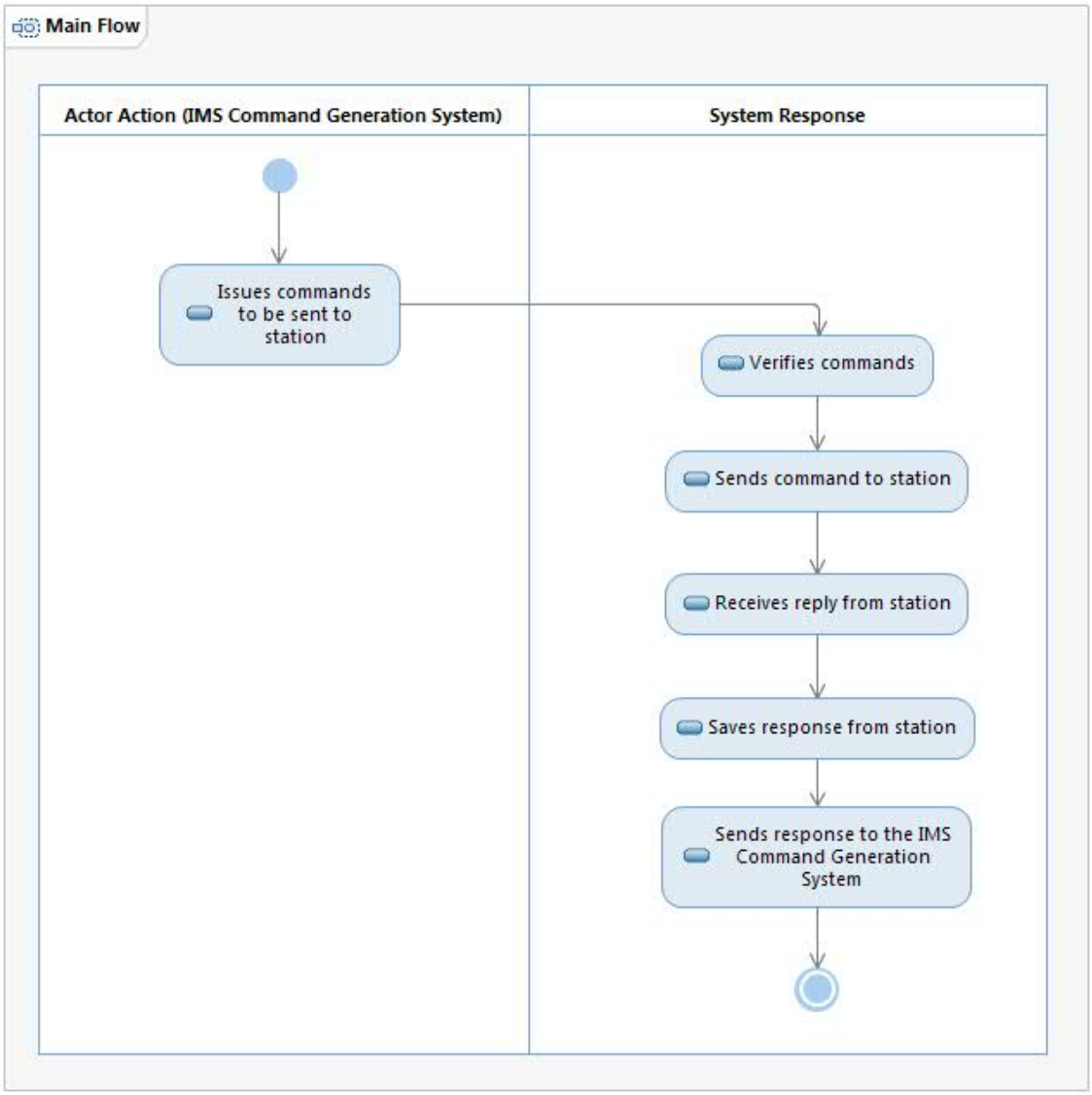
None.

POSTCONDITIONS

None.

ACTIVITY DIAGRAMS

Main Flow



Action Descriptions

Action: "Verifies commands"

The System authenticates the command from the IMS Command Generation System. The System verifies that the IMS Command Generation System is authorized to send the given type of command to the station.

Action: "Sends command to station"

The types of commands sent to the station include:
- start station calibration (SHI only)
- confirm station calibration (SHI only)
- request calibration results (SHI only)
- start detector background measurement (RN only)

- confirm detector background measurement (RN only)
- start blank spectrum (RN only)
- confirm blank spectrum (RN only)
- start calibration spectrum (RN only)
- confirm calibration spectrum (RN only)
- change operational cycle (RN only)
- confirm operational cycle change (RN only)
- send sample (RN only)
- confirm sample sent (RN only)
- confirm sample received (RN only)
- generate a new keypair
- start using a new keypair
- update Certification Revocation List (CRL)

Action: "Receives reply from station"
The System receives the response from the station, verifies its authenticity, and parses it to make sure there are no syntax errors.

Action: "Saves response from station"
The System creates a log of the responses received by the stations. The log can be searched.

Action: "Sends response to the IMS Command Generation System"
The System pushes the response/results to the IMS Command Generation System.

Alternate Flows
1. Action "Receives reply from station" - If there is an authentication problem with the response from the station, a message is sent to the IMS Command Generation System.

2. Action "Receives reply from station" - If there is a syntax error in the response from the station, a message is sent to the station.

3. Action "Receives reply from station" - If there is no response from the station, the System resends the command. If there is no response from the station after a configured number of resends, the System logs that there was no response and sends a message to the IMS Command Generation System.

SSD MAPPINGS

The following SSDs are mapped to this use case:

General:
S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

IDC Specific:

S-5586: [*IDC only, Threshold*] The System shall securely issue commands to seismic, hydroacoustic, infrasound, and radionuclide stations of the IMS network following IDC Formats and Protocols.

S-5670: [*IDC only, Threshold*] The System shall store station calibration results.

GLOSSARY REFERENCES

The following glossary terms are referenced by this use case:

General:

Random Binary Calibration - A method to determine the frequency response of a sensor using a random binary signal applied to the sensor calibrator input. A random binary signal is a sequence of step functions of identical amplitude but randomly varying polarity. The random binary signal may be a known signal or may be recorded as an independent channel at the sensor. The sensor frequency response is calculated using the cross-spectrum of the sensor output to the input random binary signal.

IDC Specific:
None.

NOTES

General:
None.

IDC Specific:
1. Commands are created on other systems. There is one system that generates command for SHI stations and a second system that generates command for RN stations.

2. Commands are sent to and from stations via a generic remote communication protocol, which current protocol documentation defines as email. The formats of the commands are defined in the document "Command and Control of IMS Stations: Procedures for Issuing Commands".

OPEN ISSUES

None.

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